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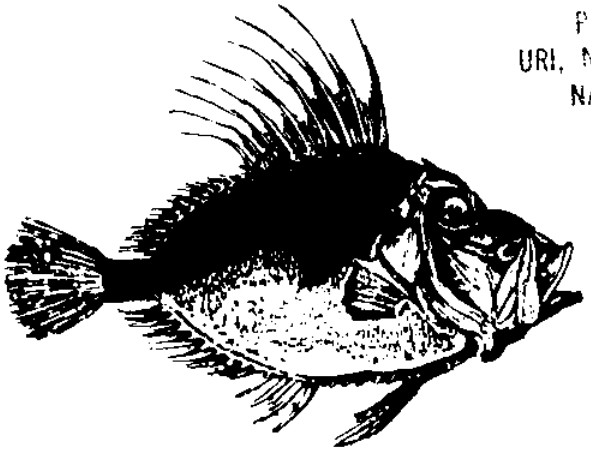
April 20-23, 1981

San Antonio, Texas



Compiled by

Ranzell Nickelson II

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SITUATION OF THE FISHERIES IN GUATEMALA

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INTRODUCTION

Guatemala has an area of 108,880 sq km and a population of 7,000,000 inhabitants. South of the country, Guatemala has 254.7 km of shoreline on the Pacific Ocean and 14,700 sq km of continental shelf. These are open waters, with no protection from bays or gulfs, and rough waters all year round. Toward the northeast, on the Atlantic Coast, Guatemala has 148.1 km of shoreline with calm waters, most of which are part of the Amatique Bay, and a continental shelf with an area of 2,100 sq km. The brackish waters are found in channels, estuaries and lagoons, and the main vegetation along the shores consists of mangroves. Fresh waters are found in the continental bodies of water like lakes, streams and rivers. Among the 300 lakes in Guatemala, the 27 largest cover an area of 950 sq km. The hydrographic system includes 1,035 km of navigable rivers.

All the above mentioned give an overview of the potential for fisheries in this country, and we can say that Guatemala is a gifted country as far as water resources are concerned. The resources have not been studied enough, however, causing the fisheries to be mainly a harvesting operation in ocean waters as much as in fresh waters.

PRESENT SITUATION

An overall protein deficiency exists in the diet of the people of Guatemala. Unfortunately, the great possibilities that exist in aquaculture and fisheries as food sources have not been taken advantage of.

The per capita consumption of animal proteins is very low, especially among low income classes and ranges from a low of 4.8 g to a high of 65.2 g/day, averaging 12.5 g/day. The consumption of fish and related products is very low at 0.46 kg per capita per day, in spite of the prices of fish being lower than those of beef and pork. Shrimp, however, is more expensive than meat. This phenomenon is partly due to the fact that Guatemala is not a traditional fisheries country and that fish is not included in the diet as a tradition.

Actually, the fisheries effort is concentrated on the shrimp industry where four private industries are operating 36 shrimpers on the Pacific and three in the Atlantic. These boats went out 592 times in 1979 for a total of 9,304 days of fishing. Landings for that year totaled 5,425,906 lbs, including: shrimp 4,131,719 lbs; fish 1,289,373 lbs; lobster 1,879 lbs; and squid 2,345 lbs (Table 1). Of these, 1,850,588 lbs were exported (Table 2). Guatemala realized an income of Q7,280,025, mainly from shrimp.

The catch is composed of white, brown and pink shrimps -- *Penaeus vannamei*, *P. stylirostris*, *P. californiensis* and *P. brevirostris*.

TABLE 1

GUATEMALA: MONTHLY CATCH OF SHRIMP AND FISH FOR 1979

MONTH	SHRIMP			FISH						
	BROWN	WHITE	PINK	CROAKER	FLOUNDER	SNAPPER	TUNA	SHARK	OTHER	TOTAL
January	31940	92254	--	42467	3765	2691	7295	4274	38752	96386
February	56418	53209	1470	33555	12698	6226	21246	626	32950	107815
March	52865	55876	445	22397	16051	7460	27709	489	26056	100162
April	93105	38900	3275	27230	20103	9246	33913	4381	32984	127857
May	79086	34216	3770	30451	22835	9677	23353	4214	35102	125632
June	51474	50702	1520	20155	14563	6602	2114	1836	22345	67679
July	68998	72301	590	33480	23436	12386	25814	4124	35159	134399
August	48442	62747	991	24576	18766	8138	5482	2400	29356	88718
September	49969	74072	533	18065	12747	5798	--	1234	19368	57215
October	94572	125270	1072	24380	18483	7984	4620	3214	28193	85879
November	72255	117323	175	29117	22307	8791	17382	2841	32616	113054
December	121396	122722	439	36170	29142	14636	59561	3350	46515	180319
TOTALS	822820	900592	13955	333569	214896	99635	228494	33383	379396	1,289373

TABLE 2

GUATEMALA FISHERIES PRODUCTS, EXPORTS 1961-1979

YEAR	SHRIMP (x 1000 lbs)	FISH (x 1000 lbs)
1961	742.9	-
1962	2297.8	-
1963	1942.5	-
1964	2206.3	-
1965	1515.0	-
1966	2480.0	-
1967	1923.5	-
1968	1315.0	-
1969	1700.7	-
1970	3001.7	-
1971	2228.7	-
1972	1746.2	-
1973	2565.7	-
1974	2234.1	-
1975	2484.0	2273.0
1976	1689.0	329.2
1977	1868.7	213.5
1978	1574.5	35.7
1979	1850.5	81.5

According to data supplied by the Ministry of Agriculture, there is a quota for 36 shrimpers in the Pacific, all of which are actually operating. For fish, out of a quota of 50, only 10 are in operation. In the Atlantic, there is a quota for 10 shrimpers and only three are operating; while for fish, out of a quota of 25, only one is in operation, and it is to take tourists on tours to the Reefs of Belize.

The fisheries in Guatemala can be divided into two groups: (1) commercial fisheries, in fresh as well as in ocean waters, the latter being the most promising; and (2) artisanal fisheries. Due to the high investments required for commercial operations and their limitations in continental waters, a new kind of fisherman has appeared. He is neither a sports nor a commercial fisherman and he usually operates in the Pacific. Artisanal fishermen now number 4,330 -- 2,100 of them

operate part-time; 3,400 of them fish in the ocean; and 860 of them are in continental waters. The problem with these fishermen is the commercialization of their catch and the lack of a means to increase it.

In 1971, a program was initiated by the government and FAO to promote artisanal fisheries in order to increase the catch by fishermen in this area and to help them market their products. The objective was, for 1980, to be producing 10,000 metric tons of fish while only 4,000 are actually being harvested, including shrimp.

The University of San Carlos in Guatemala created the Center for Ocean and Aquaculture Studies in 1978. The Center is offering courses for students to become aquaculture technicians. After three years of study, 10 technicians graduated in 1980. Actually, the Center is being reorganized and oriented towards conducting a research program in six stations throughout the country and providing extension services to give advice to communities and peasants in fish farming in western Guatemala. These programs will be developing as Guatemalans will be specializing abroad in aquaculture and fisheries.

According to a government ruling on November 19, 1980, the government must be a partner in any venture to catch tuna. According to another ruling on February 17, 1981, the capture of marine turtles is forbidden.

CONCLUSIONS

1. The development of fisheries is actually hampered by the high cost of operation at both commercial and artisanal levels, basically due to high costs in fuel and equipment.

2. The artisanal fishermen lack an organization that would allow for their development.

3. The country lacks a national fisheries development program.

4. The number of technicians trained in aquaculture and fisheries is insufficient.

5. The continental and marine fisheries resources are not well known.

6. Preservation techniques and marketing channels are not well known.

7. The University recently started a study of the fisheries resources.

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FACTORS THAT INFLUENCE THE QUALITY OF SHRIMP FROM ASIA

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INTRODUCTION

Asia has very rich resources of seafood and is trying to develop the technology to harvest and process them for the world market. Most countries in Asia have requested technical assistance from the United Nations and other international organizations to assist them in the development of their seafood resources.

Numerous attempts have been made to upgrade the seafood industry in Asia by sending personnel to specialty schools in the developed countries. This was an excellent idea, but in most cases it failed, because the wrong personnel were sent to the schools and the schools were taught at too advanced levels for understanding by the students and for implementation in the developing countries.

The developing countries need hands-on training in all aspects of the seafood industry. In most areas the training must start with very basic procedures because of very primitive conditions, lack of education, lack of equipment, and traditions. Having had several assignments in Asia to evaluate their seafood quality control programs for the world market, I have observed many conditions that influence seafood quality in Asia:

1. Animal and human pollution.
2. Product not properly iced.
3. Product not properly washed.
4. Wash water not chlorinated and coming from polluted sources.
5. Product stored on the floor or ground.
6. Product beheaded on the ground or floor.
7. Product transported in dirty straw baskets with or without ice and covered with a dirty jute bag.
8. Baskets of shrimp placed directly on the floor or ground, or in mud puddles.
9. Lack of education and training.
10. Very low sanitary conditions throughout the seafood industry.
11. Processing plants in need of repairs.
12. Processing areas not properly screened for fly and rodent control.
13. Cows, goats, cats, dogs, chickens, ducks, water buffalo, and other domestic animals in the premises where seafood is being processed.
14. No pressure chlorinated water in processing plants; products are never properly washed.
15. Wooden and concrete tables and tubs are used in the processing of products.
16. Plant and equipment never properly cleaned and sanitized.

17. Most employees are illiterate and lack personal hygiene.
18. There are no hand washing and sanitizing facilities for employees.
19. The toilets are very unsanitary and contribute to contamination of products.
20. Cold storages are not clean and product is not properly arranged for proper circulation of refrigerated air and for cleaning.
21. There are no production checks for quality.

The observations and conditions that I have outlined reveal that the basic reason for poor quality products is the lack of adequate quality control programs for the harvest areas through the processing areas with little, if any, training in general manufacturing practices, decomposition, filth, and sanitation.

Other factors that influence the quality of their products are the lack of communication or knowledge of what the importing country and the exporting country consider to be quality products and the lack of understanding of terminology used to explain the quality of the products.

Every country I visited had numerous questions on terminology. What is decomposition? What are unsanitary conditions? Why should my product be rejected for the above? You have to explain in great detail what each condition is and how it influences the quality of the product. It is very difficult to explain these conditions to them because of the way they live and exist. Flies, roaches, rats, and decomposed food are a way of life for them and they do not believe these conditions cause illness or contaminate food. So why should they worry about them in food they export? It is very difficult to convince them that to sell seafood in the world market they must produce seafood that is free from adulteration with bacteria, decomposition, and filth.

Some firms are working very hard to improve the quality of their product. They have hired experts in all phases of quality control and have implemented very effective quality control programs. They are now able to produce products that comply with all requirements of Codex Alimentaries Commission's Recommended International Standards for Quick-Frozen Shrimps or Prawns and are having no problem selling their products.

Other firms are still processing products without any type of quality control program and cannot produce quality seafood.

In every country there is at least one firm that has been producing seafood for years. Their products comply with all quality requirements for the world market. Therefore, it is possible to produce top quality products if a firm is willing to take the necessary steps to do so.

FISHES OF THE BOLINAO (PHILIPPINES) FISH MARKET

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INTRODUCTION

Due to a recent move to more fully develop marine fishery resources, certain international agencies have become very interested in what people eat, i.e., commercially important species. Published information on this subject is scant for Southeast Asia and is particularly lacking for the Philippine Islands. Philippine fish markets generally abound with diverse species. Very few fishes are considered too small or distasteful. Because of this, practically everything harvested is brought to market. The Food and Agriculture Organization (FAO) identification sheets (1974) which encompass the Republic of the Philippines do not adequately reflect this abundant diversity. Neither does A.F. Umali's 1950 work which, although useful in regards to its key to common families, is deficient with respect to its species list. These two works are the most recent reports which try to answer the question of what are the commercially important species of fish in the Philippines. From our survey of a Philippine fish market, we had the opportunity to address this question.

This study was undertaken to provide information on species composition, relative abundance, and desirability of food fishes in a particular fish market. These fishes have been designated according to habitat and assigned local names. This particular paper represents only a cursory treatment of our research data; a more detailed manuscript is in preparation.

METHODS AND MATERIALS

This study was conducted in the fish market of Bolinao, a small coastal town (pop. 30,000-45,000) located at the northwestern tip of the province of Pangasinan, Luzon, Philippines (see Murdy, 1979, for more information on the study area). From November, 1978, to November, 1979, monthly field trips were made to Bolinao (except in August, 1979, when bad weather precluded the scheduled trip). Subsequent trips were usually of 3-4 days duration and involved other work besides the fish market study. In most cases the fish market was surveyed twice a day during both the morning (0750-0900 hrs) and the afternoon (1630-1800 hrs).

Methods used by local fishermen to catch fishes included small gill nets, fish traps, spears, hand-lines and, occasionally, dynamite. It appeared that no particular fishing effort was exerted for a certain fish or group of fishes in nearshore areas; however, all fishing methods are selective in some sense. Practically every fish, no matter what size, would be collected and brought to market.

Fishermen would sell their catch at the dock to dealers. The fishmongers would then transport the catch the short distance (300 m) to the

market. The fish market consisted of two long, shaded concrete slabs (15 m each) upon which the fish were laid. No attempt was ever made to ice the fish. However, most fishes reached the market in a very fresh condition (some would even still be alive) and would be sold quickly. The fishmongers, usually 10 to 12 of them, would all tend to sell the same kinds of fishes; however, certain dealers would have only one or two types.

Our procedure was to record the names of fishes as we viewed them spread along the concrete slabs. Any fishes that could not be identified in the market would be photographed. Large specimens were photographed, preserved, and cataloged in the Marine Sciences Center, University of the Philippines fish collection. Collection data would also be noted if any pertinent information was gleaned from the fishmongers. No attempt was made to count all the fishes in the market; only a very subjective estimate of abundance was made. This procedure was repeated for every visit to the market.

We relied very heavily on Masuda et al. (1975) and Carcasson (1977) for help in identification. Transparencies of fishes of dubious identity were sent to experts for positive identification. Most identifications, however, were made in the market; we take full responsibility for any errors.

Information accumulated on observed fishes included their frequency of occurrence, habitat, and desirability. Frequency of occurrence was determined, logically, by how often a particular species appeared in the market. Habitat information was acquired from the fishmongers, our own underwater observations, and available literature. The desirability of a particular species was determined by its market price, local opinion, and, for some species, personal experience.

RESULTS

The compilation of species both observed and collected from the Bolinao market showed 286 species representing 73 families. Most of the fishes present were inshore representatives; exceptions were tuna and dolphin. More than 55% (158/286) of the fishes were classified as coral reef species with 51 other species termed reef associated.

Certain groups of fishes were much better represented than others. The eight most speciose families with the number of species for each indicated in brackets are as follows: Labridae (44), Serranidae (17), Acanthuridae (12), Scaridae (11), Gobiidae (11), Carangidae (11), Lutjanidae (10), and Mullidae (10). Thirty-four families were represented by a single species.

Fishes which were highly esteemed as food fishes included lethrinids, lutjanids, scombrids, serranids, siganids, and the milkfish, Chanos chanos. Fishes which commonly appeared in the market, but by Western standards would not normally be considered as food fishes, were members of the following families: Acanthuridae, Apogonidae, Belonidae, Chaetodontidae, Cirrhitidae, Dasyatididae, Diodontidae, Eleotrididae, Elopidae, Exocoetidae, Gerreidae, Gobiidae, Grammistidae, Hemiramphidae, Holocentridae, Labridae, Leiognathidae, Muraenidae, Myliobatididae,

Pempheridae, Platacidae, Platycephalidae, Plotosidae, Pomacanthidae, Pomacentridae, Priacanthidae, Pseudochromidae, Scorpaenidae, Synanceiidae, Synodontidae, Teraponidae, and Trichiuridae.

CONCLUSION

It is obvious from our observations that the people of Bolinao rely very heavily on their inshore fisheries, especially coral reef areas. From our limited data it is impossible to state whether or not the inshore fisheries potential is being taxed; however, it did not appear so. A possible concern may be the destruction of coral reefs by dynamite fishing, but this did not seem to be a major problem. One of the local elders mentioned that fishes used to be much more plentiful (therefore, cheaper) and bigger. Our underwater observations would verify that big fishes (> 1 m total length) are scarce in waters shallower than 12 m; however, this was typical of many other coastal areas in the Philippines as well. Much more research would be needed to gauge catch per unit effort and maximum sustainable yield.

On our next to last trip to Bolinao, it was discovered that some fishermen had begun to use hook and line near payaos (floating bamboo rafts which serve as fish attractants) in order to catch pelagic fishes. The payao method (see Murdy, 1980, for detailed information) not only offers fishermen a more highly prized catch, but it would tend to relieve pressure (if it does exist) on inshore fisheries. The initial catches of tuna and dolphin brought in by payao fishermen were sufficiently abundant to satisfy local needs and to ship some to other towns as well. It is hoped that local fishermen in other coastal areas in the Philippines will adopt the payao method in order to tap into a resource that has been almost exclusively the reserve of large commercial operators.

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PRESENT STATUS OF SEAFOOD TECHNOLOGY IN VENEZUELA

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INTRODUCTION

Venezuela has 2,800 km of coastline which can be divided into three different areas: western, central and eastern. Most of the shrimp catch comes from the western area. The eastern area, the richest of all, provides more than 65% of the fishery production. The central area is poor and produces less than 10% of the total.

The annual per capita consumption of fishery products is 9 kg, the majority of which is in the coastal areas and in the large cities.

RESOURCES

The total annual fishery production is 150,000 tons. Approximately 10,000 tons are processed as sun dried salted fish; 60,000 tons go to the canning industry; 10,000 tons are commercialized for exportation as frozen products; 70,000 tons are sold as fresh or frozen products in the domestic market; and the production of fish meal is around 6,000 tons.

Due to the fact that the data reported here come only from the government inspection offices, we can estimate that the actual catch is 10-20% greater because of the unreported catch of subsistence fishermen.

Ninety percent of the production comes from the sea; only 10% comes from fresh water.

From the abundant variety of marine species, only a few have a high commercial value. Some of them are the following:

Sardine	Sardina	(Sardinella anchovia)
Weakfish	Curbina	(Cynoscion sp.)
Red Snapper	Pargo	(Lutjanus sp.)
Spanish mackerel	Carite	(Scomberomorus sp.)
Tuna	Atun	(Thunnus sp.)
Grouper	Mero	(Epinephelus sp.)
Dogfish	Cazon	(Mustelus-Carcharhinus)
Mullet	Lisa	(Musil sp.)
Shrimp	Camaron	(Penaeus sp.)
Crabs	Cangrejo	(Callinectes sp. - Cardisoma)
Ark shell	Pepitona	(Arca zebra)
Mussel	Mejillon	(Perna perna)
Oyster	Ostra	(Crassostrea sp.)
Squid	Calamares	(Holigo sp.)

Approximately 40% of the total fishery production goes to the

domestic market as fresh fish. Ice-refrigerated transportation is used for fish distribution from the fishermen to the retailers. A small proportion of this fresh fish is frozen for short periods of less than two months.

INDUSTRY

Presently 14 factories are processing fishery products. Two of these freeze only shrimp, one factory dries imported cod (bacalao) and the other 11 are canning industries. Besides these factories, there are several small fishery communities that work with sun dried salted fish.

The canning industry is limited to three basic products: sardines, tuna and ark shell (pepitona) prepared in different manners. Sporadically they process other shellfish. Seven thousand tons of tuna and 15,000 tons of shellfish (mainly ark shell) are canned annually.

The total annual sardine catch is approximately 36,000 tons, and 90% of its goes to the canning industry. Sardines are processed in rectangular cans, either in vegetable oil or tomato sauce.

All of these commodities are produced for national consumption. In addition, canned seafood is imported from other Latin American countries and Spain.

All of the canning industries have facilities for fish meal reduction. Wastes from sardines and tuna are the source of raw material for fish meal. However, the following three fish species are only allowed to be used for fish meal production:

	Machuelo	(*Opisthonema* sp.)
Catfish	Begre	(*Arius spixic*)
Yellow tail	Rabo amarillo	(*Centengranlis edentulus*)

Since the production of fish meal is not enough for the national consumption, extra fish meal is imported annually.

Regarding dried/salted fish, 2,000 tons of cod (bacalao) are imported annually to be dried in the country. More recently, importation of other fish species such as mullet has increased. This fish comes headed, gutted and salted. The sun-drying process is done only in the country.

The traditionally sun dried salted fish is produced in Venezuela by small fishing communities. They produce around 8,000 tons of dried fish annually. This product has poor quality due to the lack of adequate technology and sanitary control during the process.

Seventy percent of shrimp catch is frozen for exportation, mainly to the United States, and 25% is sold fresh in the domestic market.

QUALITY CONTROL

The lack of quality control programs by the Seafood Industry has been the stimulus for the government agencies to apply several regulations, standards and specifications to these industries. Recently, a

program has been started, and still it is in need of modifications, improvements and support by the government agencies, industries and consumers.

The committee for the study of fishery products has established standards and specifications of canned commodities such as sardines, tuna, mussels, ark shell (pepitona), and fish meal.

The Ministry of Agriculture has a program advising and assisting both the organized fishermen and the industry, as well as the subsistence fishermen and small processors.

This program includes, among other recommendations: good sanitary practices in the handling of fish, from the fishing boats through unloading and transporting, to processing and marketing; and adequate procedures of salting, drying, freezing, packing and canning of fishery products.

In addition, toxicological tests of shellfish are performed daily as a service to the industry.

RESEARCH

The Venezuelan seafood industry does not carry out any research activity. Research programs are performed by universities and the Ministry of Agriculture. All these projects are supported by government and university grants. Among the research projects presently carried out by these institutions are the following.

1. Effect of different freezing processes on the quality of fish with high commercial value: Freezing represents the most practical way to commercialize the fish of high economic value in Venezuela. This project includes the study of the effects of several freezing methods such as airblast and plate freezing and immersion in liquid gases on the quality of these fish species. Physical-chemical, biochemical, sensory and structural changes during the process and the storage at different temperatures are investigated.

2. Enrichment of cereal and tuber flours with fish: Due to the high consumption of cereals and tubers by the population, particularly by the low income, poorly nourished group, a research program has been initiated to develop several mixtures of cereals and tubers with a low percentage (5-15%) of fish. Underutilized fish species were used. They were passed through a deboning machine after being headed and gutted manually. The fish flesh obtained was mixed with cereals or tubers and finally dried in a rotary drum drier.

Several factors related to the process, the effect of additives, types of packing, and storage stability of the final products, are being studied. Biochemical, nutritional, sensory, and economic factors related to these products have been studied also. Satisfactory results have been obtained by the use of supplemental cereal and tuber flours with fish in bakery and pasta products, breakfast meals, tortillas, snack products, and for the preparation of traditional dishes of the daily diet.

3. Processing of crabs: A great proportion of our population is not used to eating crab. Therefore, most of the crabs are exported alive or pre-cooked. However, this industry is in need of an adequate technology to process the crabs in different ways in order to comply with the exportation requirements of the processed crab, and to present appealing products to domestic consumers. Two species of crabs are abundant for commercial purposes: the blue crab (Callinectes spp.) and the brown crab (Cardisoma spp.). Several technological processes have been proposed for canning, pasteurizing, and freezing crabs.

4. Freshwater fish: Venezuela has a great potential of freshwater fish which has not yet been exploited. A research program was initiated to evaluate the resource, to determine the type and level of processing technology presently applied, to improve these technologies, and adapt the processing of these resources to several factors such as environmental conditions, type and proportion of resources, the social and economic level of the consumers and processors, industrial facilities, labor, etc.

The program was initiated with an evaluation of the resource, with recommendations for the handling of fish at low temperatures in those environments where refrigeration and transportation facilities are limited, and for improvements in the salting and sun drying process, which represents the most practical and traditional way to preserve fish in those areas.

5. Shellfish utilization: More than 90% of the shellfish production consists of mussels (Perna perna), oysters (Crassostrea spp., Pictada imbricata) and ark shells (Arca zebra).

Mussels and oysters are obtained from both natural and artificial cultures, while ark shells or pepitonas come only from natural sources. Oysters are consumed only as fresh products on the beaches or in restaurants. Mussels and ark shells are mainly utilized by the canning industry, but a small proportion is utilized locally in traditional dishes.

A research project has been initiated to diversify and improve the consumption of these resources. New ways of presentation of these shellfish have been developed with satisfactory results. In addition, non-traditional ways of processing have been considered, such as hydrolyzed mussels and mixtures of shellfish with cereals and tubers.

6. Utilization of shrimp by-catch: Presently more than 75% of the fish caught by the shrimp trawlers are discarded at sea. These fish are caught incidentally and represent an enormous variety of small demersal fish species which do not present any value in the market.

Although the quality of shrimp by-catch represents a great potential resource as human food, a variety of problems are implicit regarding its utilization. A research program has been initiated to utilize the shrimp by-catch. An evaluation of this resource in the North Central and Northeastern coasts of the country indicates that more than 30 fish species are present. However, 80% of the total volume belongs only to 10 fish species. Physical-chemical and microbiological studies have been initiated in these fish species. The project includes the feasibility

of utilization of flesh from those abundant fish species for use in dried, dried/salted, and frozen products.

This new source from fishery products is directed to those groups of people with low economic resources and with more malnutritional problems. This means that the products should be of high nutritional level and low cost. The technology applied should be simple, without the requirement of expensive and sophisticated equipment.

Finally, it is important to emphasize that most of these research projects are related to exchange or cooperation programs among several Latin American countries.

Venezuelan problems are related first to handling of fish, from fishing boats through unloading and transporting to processing and marketing; second to lack of adequate technology; third to sources of raw materials; and finally to consumer preferences for fish products, all of which are similar to those present in other Caribbean countries. Cooperative programs in this regard among these countries would accelerate the most adequate, practical and satisfactory solutions for all of us.

AQUACULTURE IN MEXICO

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Fisheries development in Mexico has been greater during the last four years than at any time in the past. The different fisheries offices which controlled processing and marketing were integrated into the Departmento de Pesca (Department of Fish), one of the 20 major dependences of Mexican government. One of the more important points of the new deal in fisheries was the establishment of 200 miles of exclusive economic zone in accordance with other Latinoamerican countries.

Traditionally, Mexico has been a Mediterranean country with little development of its coastal resources. Only 20 years ago the shrimp fisheries in the Gulf of Mexico and the Pacific Ocean were initiated, but the industrial level only arrived in the 1970's. Now the Mexican government has the participation of the Mexican Private Bank and the development of the "Plan Nacional de Pesca" (National Fish Plan) and anticipates production of 2.4 million tons of shrimp next year.

In order to reach this goal, the program is based on the construction of fishing ports, development of ship construction, and improved technology. Shrimping vessels are also used to fish for other species of fish during the shrimp off-season. The growing tuna, red snapper and bonito fisheries are now very important, especially with the purchase of new boats from Poland, Spain and the United States.

Despite this growth and Mexico's recent oil boom, half of the country's population remains hungry. Because of this, President Lopez Portillo initiated the Sistema Alimentario Mexicano for nutrition improvement which will be applied in Mexico's poorest countries. The objective is to achieve self support through production of food and, with the support of the official Bank, to increase funds to the Secretary of Agriculture and the fisheries sector which includes the Departamento de Pesca, Banco Nacional Pesquero and the branch of official commerce, "Productos Pesqueros Mexicanos".

The idea behind this strategy is to bring seafood to all of Mexico from the Mexican states which produce the greatest amounts of seafood -- Baja California, Sonora, Sinaloa and Campeche.

Only four medium-sized aquaculture facilities exist in Mexico and 1,000 employees work in 20 hatcheries. The development of shrimp and oyster aquaculture is controlled by cooperative groups of fishermen. Experimentation is also underway to locate species for aquaculture purposes for the brackish waters of coastal lagoons.

Extensive work has been done in freshwater aquaculture. Fingerlings have been raised to help stock the rivers and lakes. Technology has been

limited to four species -- trout, carp, tilapia and catfish -- however, because aquaculture technology for these species is more advanced. As a result, the production of 200,000 tons of fresh water species is predicted for next year. Meanwhile, researchers will continue to explore problems associated with ponds, food, sanity, genetics and nets.

AQUACULTURE OF MARINE ORGANISMS: A RENEWABLE BIO-RESOURCE

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A world food crisis has been predicted by people who are concerned with future protein shortages and by those who believe that harvests of animals from the sea are either at or near maximum sustainable yields. Some marine species have already been so exploited that in some countries yields and profits have decreased. During the last 10 years the per capita and total consumption of commercial fish and shellfish has increased 10 and 20 percent, respectively. The increase in demand is expected to continue.

Aquaculture, the culture of aquatic organisms under controlled environments for profit, can help augment the world's protein supply. Also, it has potential as a new industry that can provide economic growth and development for both developed and underdeveloped countries. And marine aquaculture (mariculture) need not be limited to coastal areas. For example, in West Texas, underground sand strata contain unpolluted salt water that can support aquaculture of commercially important marine animals such as shrimp. With improved technology, mariculture could develop into an industry in such regions.

Aquaculture can produce food, bait, ornamental fish and invertebrates, seedstock for other commercial aquaculture facilities and stock natural waterways such as bays and estuaries to augment the natural populations, and animals for bioassays of pollutants and other research. At present, however, the main benefit of aquaculture is as an economic resource, not as a means of food production. Most species being considered (e.g., shrimp, trout and salmon) are high in the food chain. Therefore they are expensive and consumed primarily by the middle and upper classes.

In the United States, aquaculture produces primarily non-food products such as bait and ornamental fishes. Aquaculture produces 10 million tons of food products annually, which represents only three percent of all fishery products consumed in the United States each year. In Japan, however, at least 35 percent of the seafood consumed comes directly or indirectly from aquaculture.

In the United States, the shrimp fisheries make up about 20 percent of the value of the catch of the combined U.S. fishing craft and is the most valuable of the U.S. fisheries. Still, demand for shrimp is so great that more than half the shrimp consumed in the country must be imported. Some analysts state that the market for fishery products, particularly shrimp, is almost unlimited. An aquaculture industry would reduce the negative balance of payments and help meet these demands.

Benefits of the developing aquaculture technology are striking. For example, in Latin America, shrimp aquaculture in unmanaged ponds, using wild seedstock, has produced 600 lb/acre/yr and made profits. With modern aquaculture technology, 4,000 lb/acre/yr can be produced in Latin America. It is predicted that intensive culture could produce 50,000 lb/acre/yr.

Another potential benefit of the aquaculture industry is the use of organic wastes for the production of edible protein. In my laboratory, we have shown that species of shrimp and oysters can use dissolved organic matter (DOM) and bacteria as a source of food (Lawrence et al., 1975; Schulte and Lawrence, 1078a, b; Castille and Lawrence, 1979). Under intensive culture, which optimizes the use of DOM and bacteria as food, the food conversion ratio for shrimp has been decreased from 3.0-3.5 to 2.0-2.5 (Lawrence et al., 1980). Food costs represent at least one-third of the total operating cost of shrimp aquaculture. Using waste effluents containing DOM and non-pathogenic bacteria as nutrients for shrimp would reduce the cost of culturing food shrimp. At the same time, it would create a use for some of the organic wastes of our modern society.

For development of a successful aquaculture industry, its scientific and engineering base must be considered in the context of its economic, sociological and political implications to the region and local fishery. Cooperation is also necessary among the universities and other bodies that perform the research, the businesses and agencies that fund the research and the governments of the area in which the new industry is developing.

Marine aquaculture faces another problem. Most of the industry will be based in the coastal zone, one of the world's most limited resources. The coast receives impacts of cities, industry and recreation. Also, some coastal areas must be preserved in their natural state, because the coastal zone is essential for the maintenance of the existing natural animal populations in the oceans.

As aquaculture develops into an industry, intelligent decisions on use of this limited resource must be made. How much of the coastal zone must remain in its natural state? How much should be used for urbanization? . . . industrialization? . . . recreation? . . . aquaculture? Aquaculture can both augment the world's protein supply and provide new industry, which would improve the economy of both underdeveloped and developed countries.

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SHRIMP MARICULTURE GENERAL INFORMATION AND COMMERCIAL STATUS

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INTRODUCTION

The dockside value of United States fisheries is over a billion dollars per year. In spite of this, in 1980, the nation imported 60 percent of the fishery products it consumed, which accounted for 10 percent the national trade deficit. The shrimp fishery is the most valuable of the United States fisheries with most of the shrimp coming from the Gulf of Mexico. It is notable that the value of shrimp imported for United States consumption is significantly greater than the total value of the domestic shrimp catch. In 1979 and 1980, respectively, the dockside value of imported shrimp was $731,238,000 and $719,263,000 while that of the United States shrimp catch was $471,573,000 and $402,697,000. Further, during the next decade the demand for shrimp is predicted to increase worldwide and in the United States. This comes at a time when the most traditional commercial marine animals are being hravested at or near maximum sustainable yields. For example, the amount of shrimp caught by American fishermen for 1977, 1978, 1979 and 1980 was 476,654,000; 422,881,000; 335,956,000; and 339,707,000 pounds, respectively. Shrimp mariculture could play a major role in augmenting the supply of shrimp and, at the same time provide economic benefit to our nation as a new industry.

WHAT IS SHRIMP MARICULTURE?

Shrimp mariculture can be separated into three phases: maturation/reproduction, hatchery and grow-out. The maturation/reproduction phase produces seedstock or shrimp larvae to supply the hatchery phase which in turn produces 6- to 10-day-old postlarvae. These postlarvae are used to supply the grow-out phase (e.g. ponds or raceways) which produces marketable size shrimp for human consumption or smaller shrimp for use as bait or for augmenting natural populations by stocking bays.

STATUS OF SHRIMP MARICULTURE

Status In World Exclusive of United States

Most mariculture activity involves the use of penaeids such as Penaeus japonicus, native to the northwestern Pacific; Metepenaeus ensis, Penaeus monodon, P. indicus, P. semisulcatus, and P. merguiensis, native to the western central and southern Pacific; Panaeus stylirostris, P. vannamei, P. californiesis and P. occidentalis, native to eastern

Pacific; and Penaeus setiferus, P. brasiliensis, P. duorarum, P. aztecus and P. schmitti, native to the western Atlantic. Viable commercial shrimp mariculture endeavors exist in Central and South America, Southeast Asia, Taiwan and Japan. These endeavors reply on animals from natural populations with a very small percentage coming from seedstock produced in captivity. Experimental production of seedstock in captivity is being accomplished in Australia, Japan, United States, Brazil, Costa Rica, Ecuador, Honduras, Mexico, Taiwan, the Phillippines, England, Indonesia, Mainland China, Panama, Tahiti and France. In general, the inability to adequately mature, breed and spawn shrimp in captivity is the most limiting aspect of shrimp mariculture.

Though the hatchery technology is far from optimum, it is adequate to support commercial shrimp mariculture operations for about 10 different species of marine shrimp in many countries. In fact, several commercial farms presently rely entirely on hatchery production of 6-to 10-day-old postlarvae rather than capture of postlarvae or juveniles from the wild. Also, postlarvae raised either from natural or cultured populations have been used to augment natural shrimp populations in the Inland Sea in Japan and the Gulf of Arabia.

The technology required for the pond grow-out phase is presently being utilized for commercial operations in many countries, though, again, it is recognized as being far from optimum. Commercial shrimp farms have obtained 200 to 500 pounds of 10 to 30 count shrimp per crop in about 6 months in unmanaged ponds and 600 to 1,500 pounds of 20 to 40 count shrimp in about 4 months in managed ponds. For countries where shrimp can be commercially farmed continuously throughout the year and not seasonally, an average of 2.25 crops (4 months per crop) per year is possible. Most shrimp (e.g. P. vannamei, P. stylirostris and P. setiferus) require a minimum of about 22 to 24° C for commercial growth rates.

The technology required for the grow-out phase using intensive culture methods involving raceways or tanks is not sufficiently developed for a commercial operation. Although several companies are investigating the feasibility of intensive shrimp mariculture, none that we are aware of are making a profit. However, through increased technology and domestication of shrimp, it is plausible that shrimp will ultimately be raised in raceways or tanks. A production level of 50,000 to 100,000 pounds of 30 count heads-on shrimp per year per acre of water is being predicted for intensive culture.

Status in Texas

Five species are receiving primary consideration for shrimp mariculture in Texas. These are Penaeus setiferus, native Gulf coast white shrimp; P. aztecus, native Gulf coast brown shrimp; P. monodon, a brown shrimp from indo-western Pacific; and P. stylirostris and P. vannamei, white shrimp from the eastern Pacific. There is only one commercial shrimp farm, Marifarms, Inc., Panama City, Florida, using ponds in the United States at the present time. They

have been primarily dependent upon seedstock of P. vannamei and P. stylirostris from Latin America supplemented with seedstock obtained from female P. setiferus matured and mated in the wild but spawned in captivity.

Although shrimp mariculture in Texas is relatively young in comparison to that in Japan, Taiwan, etc., our technology is approaching worldwide state of the art. Three shrimp species have been matured, mated, spawned and reared in captivity in Texas. These are the native white shrimp, P. setiferus, and two eastern Pacific white species, P. stylirostris and P. vannamei. However, the technology level for the maturation/reproduction phase is not adequate for commercialization. The hatchery and grow-out technology is adequate though not optimum for shrimp mariculture in Texas. The primary reasons why shrimp mariculture is commercial in Central and South America and Southeast Asia and not in the United States are: (1) the longer growing season (in most cases it is the year around); (2) the availability of mature and mated female shrimp; (3) the availability of postlarvae or juvenile shrimp in the wild; and (4) the availability of a cheap labor pool. The exception to these arguments is Japan, but there the price per pound for shrimp is two to three times that in the United States. Essentially, a shrimp mariculture company in the United States has to have seedstock produced in captivity in order to be successful, while this is not necessarily the case in some foreign countries.

We estimate one to three years will be required before the needed technology in the maturation/reproduction phase will be developed to a level necessary to support a commercial shrimp mariculture company in the United States.

Mariculture of shrimp for sale as live bait has a large potential because of the greater price per pound and smaller grow-out cost as compared to production of shrimp for food. However, mariculture of bait shrimp would be restricted to native species and would require a larger number of seedstock. For these reasons commercial bait-shrimp culture may not develop as quickly as culture of shrimp for human consumption.

Commercial grow-out production of shrimp requires an abundant and reliable supply of postlarvae or juveniles for stocking. These animals can be captured directly from wild populations as is presently done in some South American shrimp culture farms where labor and production requires a more manageable stocking system where predators, competitors, densitites, and stocking dates are controlled. In order to obtain monospecies populations of postlarvae of equivalent age for stocking, a hatchery phase is required. Eggs to supply the hatchery phase can originate from mated females captured in the wild or matured in captivity. The use of wild populations as a source of mated females is not recommended in the United States for four reasons: (1) supply is unpredictable; (2) non-indigenous species are not available; (3) availability is restricted to local spawning season; and, (4) genetics and selective breeding are not possible. The preferred alternative is to mature, breed and spawn the females in captivity under controlled conditions. By this approach a low-cost predictable supply of shrimp

seedstock(larvae) can be produced. A 6,000 square foot metal frame maturation/reproduction facility costing approximately $400,000 could produce about two million seedstock per day at a cost of 30 to 50 cents per thousand.

The seedstock produced in the maturation/reproduction phase are transferred to a hatchery where they normally metamorphose to postlarvae after 10 to 12 days. The postlarvae are maintained in the hatchery for an additional 6 to 10 days to increase their survivability in ponds. A 7,000 square foot metal frame hatchery facility costing about $700,000 could produce about 0.75 million 6-to 10-day-old postlarvae per day at a cost of about $3 per thousand. In comparison, shrimp postlarvae produced by this method are presently selling for $5 to $6 per thousand in Central and South America.

The postlarvae from the hatchery phase are transferred to grow-out ponds to be raised to marketable size. Ultimately, raceways or circular tanks using intensive culture techniques may be used for grow-out rather than ponds. Using grow-out ponds (probably up to 10 to 20 acres in size), the 6-to 10-day-old postlarvae can be raised to a 25 to 35 count heads-on shrimp in approximately 4 months. One to two thousand pounds of shrimp can be produced per acre per crop having a value of $2,200 to $4,000 with an operating cost of approximately $1,300 to $1,800 per acre of water. The operating cost will vary with the size of the ponds and total number of acres of water. To complete the cycle, some of the reared shrimp can be maintained in the ponds for another two months and these animals can then be used as broodstock in the maturation/reproduction phase.

CURRENT RESEARCH IN UNITED STATES

Approximately 40 percent of the current research on shrimp mariculture in the United States is by industry. The Texas A&M University System has the largest shrimp mariculture research program in the United States, constituting about 30 to 40 percent of the total effort. Presently, the university and federal laboratories are contributing more research than the private sector. This is as it should be for two reasons. First, much of the information required is too basic and too expensive for private enterprise. Second, and very important, is because of the understandable special interest and proprietary nature of private industry, it is important that most of the basic information and a significant amount of the applied technology be in the public domain area so that full development of shrimp mariculture can be guaranteed. Obviously, the research should be funded from both public and private sources.

SUMMARY

Interest in shrimp mariculture is increasing for the following reasons:

1. The harvest of shrimp from the oceans is either very near or at maximum sustainable yields.
2. The price of shrimp is increasing and there is potentially a large margin of profit per acre for raising shrimp commercially.

3. The market for shrimp is very large (over one billion dollars dockside value per year in the United States) is increasing.
4. Commercial shrimp mariculture, particularly in Central and South America (e.g. Ecuador), is very successful.
5. The level of technology available for shrimp mariculture is rapidly increasing.

Shrimp mariculture consists of three phases: maturation/reproduction, hatchery and grow-out. Additional technology is required, particularly in the maturation/reproduction phase, before commercial shrimp mariculture becomes a viable industry in the United States. In fact, the maturation/reproduction phase is most limiting to the commercial development of shrimp mariculture worldwide.

MARKET DEVELOPMENT IN THE MIDWESTERN U.S. FOR GULF AND SOUTH ATLANTIC SEAFOODS FROM 1977 TO 1980

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INTRODUCTION

Large quantities of underutilized seafoods in the Southeastern U.S. enjoy only regional acceptance. Other species at the present time are virtually unutilized. These fishery resources can provide the base for expanded harvesting, processing and marketing operations. Identification and stimulation of new markets is essential to the development of these resources.

Market penetration of existing markets and development of new markets for these products has been the goal of the combined efforts of many seafood marketing agencies from the states of Virginia through Texas since 1977. The Gulf and South Atlantic Fisheries Development Foundation (a private non-profit corporation) has served in a coordinating role for a part of the overall marketing program of the various state and federal agencies in the market expansion and penetration program.[1] The Coastal Plains Regional Commission has been the major funding source for the overall Midwest marketing program. Both financial and in-kind support has been utilized in introducing seafood products from the Southeast into Midwest markets in an attempt to gain market acceptance of the products.

The purpose of this paper is to outline the coordinated seafood marketing program, which has often been referred to as the Midwest Marketing Program. The target market strategy utilized is outlined, the amount of promotional effort that has gone into the marketing program is discussed, and then the comments will conclude with an overview of the measured success levels of the marketing program. Detailed discussions of these activities can be found in (1), (2), (3) and (4).

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[1]Agencies and groups that has been involved in some aspect of the marketing program are:

Coastal Plains Regional Commission
Gulf and South Atlantic Fisheries Development Foundation
National Marine Fisheries Service
Florida Department of Natural Resources
North Carolina Fisheries Association
South Carolina Wildlife and Marine Resources Department
Virginia Seafood Council
University of Georgia
University of North Carolina Sea Grant College
North Carolina Department of Marine and Seafood Development
Virginia Institute of Marine Science
Virginia Polytechnic Institute and State University
University of Florida

MARKET STRUCTURE OF THE SEAFOOD INDUSTRY

The commercial fishing industry of the Southeastern United States is comprised of many small producers spread over a wide geographical area. Each operator is relatively independent of the other. The economic power, financial structure and market dominance of any single producer are so small in relation to the total industry that each has negligible, if any, influence on the industry as a whole. In essence, the commercial fishing industry approaches the economist's description of pure competition.

One important characteristic of pure competition and the commercial fishing industry is that the price for fish offered by the buyers to any one firm is very elastic. Also, no one firm can produce enough fish to affect the market price. Only total industry supply tends to change the price for fish. Consequently, the fisherman is a "price taker" and alone cannot influence the price received. No buyer will offer a higher price for one fisherman's fish as opposed to another fisherman. As a price taker, the only way the fisherman can increase per unit profit is to decrease per unit costs. There is no incentive for a fisherman acting alone to incur costs to differentiate product from other suppliers, nor is there any incentive to promote the product to receive a price differential above the market price. However, there is an incentive for the total industry to promote its product to gain an advantage over other food or meat substitutes and to open new markets.

For these reasons, the state and federal agencies, through their seafood marketing divisions and development sections, initiated programs to improve the marketability of domestically harvested products. These programs are sometimes generic in nature or they may be designed to achieve a specific set of goals within a prescribed geographic area, time frame and for a given species. The overall goal is to increase the demand for the products promoted in order to cause a higher price to be paid to the fisherman or to increase the amount of product sold primarily in existing and new market areas so that the fisherman can lower per unit costs through producing larger volumes and benefit from higher profits.

MARKETING STRATEGY

The initial problem faced by any marketing program is not "how should we promote?", but "should we promote?". Since the Midwest Marketing Program has been in effect for a number of years with the "should we promote?" decision already made, this paper will concentrate on the strategies used to guide the promotion and to choose the target market's products, and will conclude by outlining the results of the marketing program. A good review of a method that can be used to answer the "should we promote" question can be found in

Promotional Strategy

The same format was used during all four years of the Midwest Marketing Program (MMP). A selected number of fish and shellfish species

were selected for introduction into target city areas focusing on the popular seafood periods around Lent and during the October "seafood month". A marketing team, generally consisting of a home economist and a marketing specialist, visited retail food chains, intermediaries and media agencies in each city and many nearby suburban population areas. The nature and scope of the program was explained and their participation was encouraged. Media firms, such as newspapers and magazines, were requested to print food releases, photographs and consumer education information developed specifically for the species promoted. Television and radio stations were asked to donate public service time or "talk-show" time for educating the consumer about the selected seafood products. Retailers, particularly supermarket food chains, were contacted by the team, informed of the program and were encouraged to have sufficient supplies of product available. They were also encouraged to tie-in their in-store promotions or paid advertising with planned newspaper food releases and public service programs. Intermediaries such as brokers, distributors and wholesalers were informed of the marketing program and encouraged to contact Southeastern coastal suppliers in order to have sufficient product available to support the retailer's efforts in merchandising these items. Coastal suppliers were also asked to have the promoted products ready for sale and distribution.

Target Market Strategy

The criteria for selecting target city areas were: (1) they were inland areas where until a few years ago, except for shrimp and red snapper, practically no seafood from the Gulf and South Atlantic was marketed, (2) they were industrial states with population concentrations in major metropolitan areas, (3) they were relatively strong seafood markets for non-Southeastern species--particularly from the Great Lakes and Canadian freshwater fisheries, (4) there appeared to be adequate trucking capabilities for fresh and frozen items shipped by Southeastern dealers and distributors to the Midwest, (5) they had a well-established set of distributors and supermarket retailers familiar with handling and merchandising seafood, (6) past marketing programs were beginning to show success in the area, and (7) several represented fringe areas just beyond the previous geographic promotion area.

During 1977, promotional visits were made to 16 cities in eight states of the Midwestern U.S. The geographical area covered each year increased and by 1980, a total of 37 cities in 18 states and two Canadian provinces were visited.

Product Strategy

The Midwest Marketing Program (MMP) has been committed to developing the market demand for species of finfish and shellfish indigenous to Gulf and South Atlantic waters. The marketing teams usually promote all species with three or four selected for priority based on current industry needs and requirements and/or market conditions. Species that received priority during the 1977-1980 marketing program period are mullet, Spanish mackerel, croaker, bluefish, oysters, blue crab, king mackerel, grey trout, shrimp, rock shrimp, shark, and swordfish.

MEASUREMENT OF PROMOTIONAL EFFORT

Marketing effort in the MMP has been measured in two ways. First, the number of contacts that have been made to retail food chains, seafood retailers, institutions, restaurants, brokers, wholesalers, distributors, etc. were tabulated. Second, the value of television and radio time and the value of newspaper food column advertising were estimated.

The total number of contacts increased in each of the marketing program years (Table 1). Increases occurred in each of the contact categories with the total reaching a high of 6,881 during 1980.

Table 1.--Total contacts by type during the 1977-1980 Midwest Marketing Program.

Contact Type	Year			
	1977	1978	1979	1980
Personal	307	275	475	518
Telephone	224	188	420	601
Mail	334	1,028	1,046	5,762
Total	885	1,491	1,941	6,881

Media promotions occur in the form of radio and television appearances to promote the seafood products and advertising space through newspapers in the food editor sections. This electronic and printed media time is donated but represents advertising value if it had to be purchased. The only cost in acquiring this advertising is preparing food photographs and other materials, visiting and/or calling the media outlet and securing the commitment to use the materials or presentation of the home economist or marketing specialist. During 1977, the total value of television, radio time, and newspaper advertising was estimated at $232,000. Many of these photographs of food are used continually for other newspapers and in other locations. Based on historical and predicted use patterns, it was estimated that the total value of printed media, using the 1977 materials over the next three years, would be $800,000.

The otal value of 1978 newspaper and television time was estimated at $325,000 in the Midwest market target area with another $62,000 generated outside the target area. The projected long-term use value of these materials was estimated at $1.2 million. Advertising values during the 1979 and 1980 marketing years were estimated at $824,000 and $675,000, respectively. No long-term use values were estimated for these years.

PROGRAM EVALUATION

Several different methods were used to determine the effect of the marketing program on seafood sales in the Midwest. These range from an

an attempt to measure the effect on prices paid for certain species in the market after the promotion program to surveys made to measure actual sales and the perceptions of both buyers and sellers as to the program's impact in the market.

Marketing During 1977

Price Effect

The desired result of the 1977 market expansion program was to increase sales of croaker, black mullet and Spanish mackerel. A maximum estimate of the total program effect resulting from increased prices at the producer level was $355 thousand. This estimate represents the increase in prices for these three species from 1976 to 1977 with the effect of inflation removed and adjustments for the effect of different quantities landed on price. The net effect must be considered the maximum since it assumes that all remaining price increases were due to the promotion effort.

Dealer Survey

A total of 24 seafood suppliers/processors were identified as product suppliers for interested Midwestern buyers during the 1977 program. Eleven of these were interviewed in order to gain their perceptions of possible benefits derived from the MMP. Comments of these dealers represented the Western Gulf, Florida, and the Middle and South Atlantic regions.

Western Gulf.--Of three dealers interviewed, two felt the MMP was the cause of new sales experienced in the Midwest. One dealer mentioned a 30 to 50 percent increase in croaker sales to Chicago. Another dealer received requests, but buyers wanted product forms that were not available. Many small lots of one to three thousand pounds of fresh product on ice were requested, but these requests were not economical for dealers because of high transportation costs for small lots. Requests could have been filled with frozen croaker in the round, but buyers did not want this product form.

Florida.--Florida dealers appeared to find new Midwest markets. Dealers who found new customers had a common market strategy--they shipped in full truck loads made up of a multiple of species such as shrimp, lobsters and snappers in addition to the promoted products. The success in this strategy appears to be (1) a reduction in per unit transportation cost, (2) servicing a wider range of new buyer needs, and (3) introduction of new species as "tie-in" sales with more customary products such as shrimp.

Middle and South Atlantic.--Four of five dealers surveyed in the Middle and South Atlantic states provided useful information. Three of the four dealers did not benefit from the program because they had no product to sell. All three received numerous new customer requests for the promoted species with potential increases in sales estimated as high as 50 percent for croakers. Unfortunately, this was a low production year in the area and, in one case, the promotion did not take effect until after the peak production season. This is a difficult problem to overcome since seasons vary along the coast. Promotion during the season for one geographic area may not coincide with the

season in another area.

The new buyers often requested products packaged and/or processed to a greater degree than is customary in the Southeast. One dealer who benefitted from the program often handled referrals from other dealers who could not fill requests. This dealer's success, in part, was due to shipments of loads of multiple species such as snappers, groupers, black sea bass, scallops, pollock, squid, octopus and shrimp in addition to the promoted products.

Perceptions of the Buyers

Retailers and distributors in Cleveland, Columbus, Detroit, Chicago, Minneapolis, Milwaukee, and Indianapolis were interviewed to learn of their perceptions of the MMP. Their perception of the success of the marketing program in terms of the volume sold of these species ranged from moderate to little interest in the species. For example, in Detroit there appeared to be a good reception for mullet and croaker, particularly in the winter months when the lakes are frozen over and it is impossible to get good supplies of freshwater mullet and sheepshead. One buyer sold 8,000 to 10,000 pounds of mullet and croaker during the winter of 1977 after learning of their availability. In Cleveland and Columbus, market acceptance was moderate to weak. All buyers contacted commented they were purchasing these species from the Southeast prior to the MMP and saw no appreciable increase in the volume sold. One Cleveland buyer indicated a small market demand for Spanish mackerel while another said there was a small but stable demand for mullet and croaker among the ethnic market segments. Another Cleveland dealer felt there was an untapped market for less expensive fish in some of the middle and lower income areas.

A Columbus buyer sold no croaker prior to the MMP but began to sell 2,000 to 4,000 pounds a month. Croaker and black sea bass permitted a broader fresh finfish product assortment. Seatrout, black sea bass and croaker had sales potential because they were worked into the product assortment more easily since they pass as reasonable substitutes for lake perch, rock fish, or pike.

Reception in the Chicago-Milwaukee market was weak. One buyer had been bringing fresh and frozen mullet from the Southeast for over 20 years and saw no change in demand as a consequence of the MMP. Another Chicago distributor commented that consistent supplies of mullet, croaker and Spanish mackerel could not be assured although Spanish mackerel could be sold easily.

Results of the marketing effort in Minneapolis were weak. Two buyers encouraged retailers to sell mullet and Spanish mackerel but never received a single reorder. Their assessment of the failure was that the market in Minneapolis is a freshwater finfish and fresh cod market. The large Scandinavian population and the relatively small black population segments result in a weak market for Southeastern species.

Marketing During 1978

A mail survey was conducted with potential suppliers (dealers) of bluefish, oysters and blue crabs (target species in 1978) from Maryland through Texas and with potential buyers of these products in the Midwest

during 1978. Suppliers were asked to comment on questions pertaining to sales volume, prices, new markets, product availability and other questions relating to market success in the Midwest. Buyers in Midwestern target cities were asked to comment on their perceptions of the marketing program, type of products normally handled, any increased sales during October 1978, the visit of the marketing team and the usefulness of the materials and media promotions made available.

Forty-six percent of the seafood buyers and 60 percent of the dealers responded. Although a higher response rate was obtained from the dealers, less useful information was contained on the survey forms due to failure to adequately respond to all questions.

Buyer Perceptions

Several types of seafood outlets represented in the survey. The most frequently indicated types were retail seafood markets and supermarkets with 19 and 18 firms reporting, respectively -- thirteen firms reported being institutional buyers. Nine restaurant firms and 10 wholesaling and distribution firms also responded. Other firms responding indicated their type of business as brokers, commissaries, meat markets, food cooperatives, etc.

The number of seafood outlets represented in the survey was considerably larger than the number of responses because of multiple outlets or customers. The range in number of outlets or customers was from one to 6,000. Nine firms reported over 1,000 outlets each.

Seafood buyers responding handled a wide variety of seafood products. Most firms (94 percent) reported they handled frozen seafood products. In addition, nearly two-thirds had fresh products available. Seventy-five percent carried fillets.

New or Expanded Sales.--The market expansion program appeared to be most successful for oysters with 53 percent of the firms reporting new or expanded sales. All types (restaurants, brokers, etc.) reported increased oyster sales. New oyster sales were reported in nearly all areas where the promotion occurred. Thirteen firms indicated an average monthly increase in oyster sales of $3,984. Only 14 percent and 13 percent of the firms reported new or expanded blue crab and bluefish sales, respectively.

Nearly half the firms reported having new or expanded sales of other seafood products from the Gulf or South Atlantic during the Fall of 1978. However, 10 of the 26 firms with new sales did not report new or expanded oyster, blue crab or bluefish sales. In total, 42 of the 63 firms buying seafood (67 percent) had new or expanded sales of some Gulf of Mexico or South Atlantic seafood product. Most frequently reported "other" products, in order of requency, were shrimp, red snapper, croakers, sea bass, and others. In addition to the expanded sales of croakers, Spanish mackerel and/or mullet in 1977. Seventy-seven percent of these firms were making repeat sales in 1978.

New or expanded sales appeared to be related to size of firms in terms of number of products handled. Firms handling four or more product forms made up 44 percent of total firms. Sixty-four percent of these firms experienced new or expanded sales of bluefish, blue crabs and/or

oysters compared to 40 percent for firms with less than four product forms. These comparisons suggest larger payoffs from promotions directed towards "full-time" larger firms.

Promotional Materials.--Seafood buyers were also asked to indicate the effectiveness of promotional materials offered through the MMP. The two general types offered were point-of-purchase materials and media advertisement.

Point-of-Purchase Materials.--Fifty-seven percent of the firms indicated recipe brochures were an effective means of product promotion. Window signs, price cards and recipe tear-off pads were second in importance, each receiving an effective rating from 34 to 36 percent of the buyers. Price cards were noted as being most effective in terms of numerical ranking by four of the 10 firms who gave numerical rankings. Posters received two first place votes and were checked effective by 32 percent of the buyers. Freezer strips, die-cut pictures and newspaper art reproductions were judged essentially equally effective with from 21 to 23 percent of the firms noting their effectiveness. Overwire hangers were by far considered to be the least effective promotional material.

Some firms, such as restaurants and institutional brokers servicing restaurants, felt all materials were inappropriate. These firms suggested items such as "table tents" and "menu clip on" items. Later promotional materials included some new items such as price cards, recipe tear-off pads, table tents and "menu clip on" items.

Even though most firms felt at least some of the promotional items were effective, only 28 percent indicated the promotional items were used. However, all firms did not receive materials and/or were not aware they were available. It should be noted that 11 of the 14 firms indicating they used the materials recalled being visited by MMP personnel.

Media Advertisement.--Forty-two percent of the buyers were aware of the food editors column promoting bluefish, blue crabs and oysters. Seventy-eight percent of the buyers responding felt the columns were an effective means of promoting these items. However, only 20 percent indicated that they also had promotional programs to coincide with the food columns.

Awareness of the newspaper columns appears to be important in the buyer's decision to promote seafood items. Eighty-six percent of those not promoting were not aware of the columns while nearly 40 percent of those who were aware of the columns had a coinciding promotion.

Some buyers may use the columns as a substitute for their personal promotional programs. Approximately 28 percent of those not sponsoring a promotion program to coincide with the columns felt the columns to be effective.

Expanded Sales and Promotions by Type of Buyer.--It was noted previously that only 28 percent of the firms reported using the promotional materials. However, nearly 86 percent of those using the promotional materials did achieve new or expanded sales.

Use of promotional materials and their effectiveness appears to be related to type of outlet or firm. In-store point-of-purchase materials appeared to be most appropriate for retail seafood markets. Sixty-five percent of the retail seafood markets used the promotional materials. These firms represented 47 percent of the firms with new or expanded sales. Forty-three percent of the wholesaling and distribution types of outlets used the promotional materials. However, most of these firms also had retail seafood markets.

Supermarkets accounted for 23 percent of the firms with new or expanded sales, although only 7 percent of the supermarkets used the promotional materials. However, newspaper food editor columns may have been partly responsible for increased sales in supermarkets because of the tendency to have supermarket ads in related sections of the newspaper.

Supplier Perceptions

Forty-three percent of the dealers surveyed who handled blue crabs, bluefish and/or oysters had new or expanded sales of these products in 16 of the 22 target Midwestern cities in 1978. Twenty-seven new or expanded sale locations were noted. This is an average of 2.7 new or expanded accounts per dealer with a range for individual reporting dealers of one to six. Pittsburg was the most frequently reported Midwestern city for new or expanded sales. Chicago, Des Moines and Detroit were second with three each.

Nearly 35 percent of the dealers reported increased sales because of more volume sold. Twenty-six percent indicated higher prices were responsible for increased sales levels. Increased monthly sales of blue crabs and oysters each ranged as high as $20 thousand per month. Increased bluefish sales were estimated as high as $500 per month. No supplier noted any carry-over effect of the promotion program on sales of other Gulf of Mexico or South Atlantic products with the exception of the 1977 target species.

The effect of the 1977 market promotion program for Spanish mackerel, mullet and croaker had carry-over effects for dealers in 1978. Fifty-seven percent of the deailers indicated repeat sales in 1978 from newly developed markets in 1977.

Marketing During 1979

A survey was also conducted with seafood dealers and processors who were potential suppliers to Midwest buyers in early 1980 to assess the sales successes of 1979 marketing efforts. A sample of 194 seafood dealers and processors were selected to receive mail questionnaires. Fifty dealers listed by the MMP literature as potential suppliers were included in the sample. The proportion of the sample selected from each state was equal to the proportion of total number of dealers and processors in the Southeast that were located in each state. Twenty-four percent of the questionnaires were returned. Forty-six percent of the dealers listed as potential suppliers responded to the survey. Results of the mail survey are discussed with respect to (1) sales response, (2) overall program evaluation and problem areas, and (3) analyses of responses of those seafood dealers directly involved

with the 1979 market promotion program.

Sales Response

Fifty-six percent of the seafood dealers and processors had sales to the selected set of Midwest cities. Forty-six percent had new sales and 49 percent had increased sales in 1979. Considering only the firms with sales in the Midwest, 83 percent had new sales and 87 percent had increased sales.

Chicago and Boston, with 34 percent and 32 percent, respectively, were the cities where the largest percentage of dealers had sales in 1979. Over 20 percent of the seafood dealers and processors had sales in ten of the cities. Some sales were reported in each of the cities where promotional activities occurred.

New seafood sales were reported by dealers and processors in 68 percent of the cities with promotional activities. Boston and Montreal were the leading "new sales" cities with 20 and 17 percent, respectively, of the dealers and processors reporting new sales. No new sales were reported in Minnesota and Colorado.

Increased seafood sales were reported in over three-fourths of the cities. Again, Boston was the leading city with 20 percent of the dealers and processors reporting increased seafood sales in 1979. It should be noted that Boston was a new city in the 1979 promotional program. Success in the Boston market suggests broader coverage, in terms of expanding the program into new cities, may give a higher marginal return to future promotional efforts. Results in the new cities of Providence, Montreal and Denver also support this conclusion. Cleveland, Chicago, Memphis and Denver followed closely with 17 percent of the dealers and processors having increased sales in each of these cities.

Increased sales to the total Midwest seafood market, including cities other than those in the program, was reported by 34 percent of the Southeastern dealers and processors of seafood products. Eight percent reported decreased sales while 38 percent felt total sales volume to the Midwest was about the same.

Program Evaluation and Problems

Seventy-two percent of the seafood dealers and processors were aware of the Midwest Promotion. In addition to favorable responses with respect to the overall program, a few problem areas were noted. Information with respect to the program is not considered timely by some dealers. Seasonality of production should be specifically considered in market promotional efforts in order to coordinate dealer supply with demands generated by the promotional efforts. Even when seasonality in production is not a factor, dealers need to be informed of the timing of promotional efforts in order to have the desired quantitites and quality of seafood products available.

Newspaper promotion was noted by one dealer as being the most effective means of promoting seafood products. However, the specific species promoted was questioned by another dealer. It was felt that promotion of certain species was not necessary because of existing strong demands for these species. Promotional efforts should be

directed to lower-priced, underutilized species.

Two problems noted in previous evaluations of the promotion program were again noted. These were transportation and adequate supplies. The transportation problem noted was that buyers often do not need a full truck load each week. More coordination among sellers and among buyers may enable more efficient transportation through combined assembly and distribution systems.

The second reoccurring problem was that of having an adequate supply of seafood products to meet buyer demands. Fifty-five percent of the dealers noted supplies were inadequate to meet demands in new markets while 47 percent noted supply problems in meeting requests in older established markets. A market promotion program can do little or nothing with respect to reducing supply problems when physical limits on production are the reason for the supply problem. However, timing of promotional efforts may lessen supply problems when seasonality of production is the reason for inadequate supplies.

Primary Dealers

There appeared to be additional benefits to these individuals who were involved more directly in the total promotional effort. Forty-six percent of the involved firms responded to the survey compared to 29 percent of all dealers and processors. Seventy percent of the 50 selected dealers had sales in the Midwest compared to 56 percent of all dealers. Of those with sales in the Midwest, 63 percent had increased sales. Being involved in the program may have also helped in coordinating an adequate supply with market requests. Of those commenting on adequacy of supply, 67 percent noted supply was adequate to meet market demands.

Marketing During 1980

During evaluations of the 1977, 1978 and 1979 evaluations, estimates of the sales success levels of the marketing program were made. No attempt was made during the 1980 evaluation to measure Midwest market program domestic sales response. All effort was devoted to measuring the effects of export marketing programs.

CONCLUSIONS

The specific objective of the Midwestern Marketing Program was to develop new and more widespread markets for Southeastern fish and shellfish. In addition to achieving its prime objective, the Midwestern Marketing Program contributed several other benefits to Southeastern seafood suppliers and fishermen. These are renewed business contacts, increased sales of other seafood products, market contact efficiencies, linkages to more distant markets, and increased probability of success for future programs.

During the evaluation surveys, many Southeastern suppliers indicated they had sold to some of the target cities and buyers in these cities in years past, but for one reason or another had not sold to them in

the last few years. The Midwestern Marketing Program, through personal contacts with target city buyers and subsequent product exchange with Southeastern suppliers, renewed several business relationships which had been permitted to wane. Hopefully, these business relationships will continue to strengthen and surpass the previous ones in both importance and duration. It is significant to repeat that 57 percent of the dealers responding to the mail survey about the October 1978 program indicated repeat sales in 1978 from newly developed Midwestern markets in 1977.

Seldom does a marketer call upon a buyer with a product assortment and sell only one of his products to the prospect. The normal consequence is that the supplier makes an effort to sell a variety of items from his inventory. Not only does this increase total sales volume and gross profit to a single customer, but also increases unit profits since handling, shipping, billing, selling and other distribution costs are spread over more items. If some of these costs are fixed, then these costs are less on a per unit basis than if only one item was sold.

This concept of a few promoted items leading to many items being sold had a synergistic effect for the program. If a supplier sold a particular product to a Midwestern buyer, the buyer might substitute one of these items for another currently purchased from the supplier. This "cannibalistic" effect was not reported. Sales of promoted products has enabled suppliers the opportunity to sell other inventory items once buyers were contacted.

In addition to more efficient distribution costs through multiple item sales, the Midwestern program also permitted market contact efficiencies. This experience contributed significantly to rapid program execution and efficient contact development. Ancillary to contact development is that subsequent contacts with meat merchandisers of supermarket chains where professional associations were developed and contacts with brokers resulted in a single contact and decision affecting the business behavior of many additional single retail stores. The economics of this type merchandising influence are difficult to measure but, needless to say, are very significant.

The Midwest is a gateway to the Great Plains and Rocky Mountain states. One of the benefits of the Midwest program is that it permitted suppliers to have an intermediate customer to the Western market area. Interim markets permit suppliers to spread their distribution costs over a larger set of customers and result in these suppliers expanding market penetration into geographical markets which, prior to these, were unprofitable or marginally profitable to service.

Finally, benefits can continue to accrue to constituents of the Gulf and South Atlantic fisheries if there are future programs similar to the Midwest Marketing Program. One program does not ensure future success. Future success requires repeated excursions to the Midwest. Marketing teams must make several trips each year for several years in order to achieve an acceptable level of product/supplier awareness and identity. Many Southeastern suppliers have

made little if any effort to establish business relationships in the Midwest because of their size. These relationships develop as a consequence of repeated contacts. A significant portion of these contacts are made by the various marketing teams which bring the good news of promotion materials, food editor placements in newspapers, and information on Southeastern suppliers' inventory situation and outlook.

Most of the unplanned but beneficial effects are the result of a move toward a position of better knowledge. These results are consistent with the theoretical models of consumption and market behavior which imply that the market works best with perfect knowledge on the part of buyers and sellers. At the outset, it appears that achievement of the primary objectives of the Midwestern Marketing Program might be limited to benefitting only the species of primary promotion activity. On closer analysis, it is clear that many species of seafood harvested along the Gulf and South Atlantic receive direct long-run benefits from the program. Additionally, all marketing channel participants--harvester, dealer, distributor and retailer--have the opportunity to enjoy more sales volume and new profits.

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THE MARKETABILITY OF PRAWNS (Macrobrachium rosenbergii) IN RESTAURANTS IN SOUTH CAROLINA: A PRELIMINARY ANALYSIS

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INTRODUCTION

In South Carolina there is substantial interest in farming prawns, Macrobrachium rosenbergii (Sandifer and Smith, 1976; Smith et al., 1978, 1981). However, prospective growers need information on the market potential for the prawns before undertaking any investment. A previous test marketing study in South Carolina explored the market for prawns in seafood retail outlets (liao and Smith, 1980). Results indicated that medium size fresh prawns were preferred by most seafood retailers. More recently, a study was conducted to examine the market potential for prawns in the restaurant trade. This study focused on the evaluation of prawns by restaurateurs in regards to: product form and count size preference; various prawn entrees; factors affecting acceptance of prawn products, and willingness to purchase prawns. This paper summarizes the results of the restaurant marketing trials.

METHODOLOGY

Seven seafood restaurants located in four counties in South Carolina were selected for the marketing test study. They were visited and details of the project were carefully explained to them. Small samples of prawns (5 lbs) were delivered to each restaurant and a list of recipes included for informational purposes. After allowing the cooks time to familiarize themselves with the product, a larger amount of ungraded whole and/or tails products, in fresh and/or frozen forms, was delivered for the actual marketing test during October-December, 1980. During the test period, some publicity about the study was presented on television, radio, and in local newspapers. After marketing trials were completed, detailed evaluation of the product was obtained from managers and chefs of participating outlets.

As part of the survey, consumer questionnaires were provided to the restaurant managers for distribution to customers who purchased prawn entrees. The questionnaires provided data concerning the consumer's (1) visual and organoleptic evaluation of the product; (2) type of prawn entree ordered; (3) comparison of prawns and saltwater shrimp; (4) willingness to purchase the prawns again; and (5) miscellaneous comments on the prawns. A total of 137 usable questionnaires were received.

RESULTS

Restaurant Manager's Reaction and Acceptance

South Carolina pond-reared prawns were served as whole animals in four restaurants and as tails in three restaurants. Dinner portions consisted of four to 12 prawns depending on type of entree. Prawns were prepared sauteed, steamed, broiled, stuffed, and microwave-oven cooked. Dinner prices ranged from $5.95 to $12.00 per serving. Two restaurants also served prawns as "cocktail" or appetizer dishes which consisted of 1/4 to 3/4 lb servings of prawns. Prices charged for these "cocktails" ranged from $3.00 to $7.50. During the test period the prices charged by restaurants for prawns were almost identical to those charged for saltwater shrimp.

Restaurateurs were asked to evaluate the product in terms of freshness, appearance, texture, and taste. About 71% of the restaurateurs rated the freshness and appearance of the prawns as very good to excellent, while 86% of the restaurateurs indicated a good to excellent rating on the texture and taste. When restaurateurs were asked whether they would purchase South Carolina prawns for their restaurant operations, five responded positively and two indicated "maybe" as their answers. When restaurateurs were asked what price they would pay relative to saltwater shrimp, the response was: 43% would be willing to pay prices equal to those charged for saltwater shrimp; 43% would pay lower than saltwater shrimp prices; and 14% would pay higher for the prawns.

Most restaurateurs indicated that prawns were an acceptable product with good sales potential. Managers were very receptive to serving prawns in their establishments; however, some cooks felt that the preparation of prawns required additional handling not typical of other entrees which they served. Specifically, they were concerned with preparation time and lack of uniformity in count size.

Consumer's Reaction and Acceptance

Consumers of the prawn dishes were asked by the restaurant managers to rate the prawn entrees with regards to appearnce, texture, taste, and price. The responses were quite favorable. With the exception of the price, all prawn dishes rated high in all categories. Microwaved and stuffed with crab meat received the highest evaluation in all categories.

About 60% of the consumers indicated that they would definitely buy prawns again if available, while 23% indicated they might purchase them again. The remaining 17% chose not to purchase prawns again. Their negative comments dealt mostly with the "taste" or "texture" of the products. The most popular entree consisted of microwave cooking of prawn tails stuffed with crab meat. About 81% of 47 consumers who ordered this entree indicated that they would order it again.

Consumers were asked to compare the organoleptic qualities of prawns and saltwater shrimp. About 49% of the consumers rated the quality of prawns similar to saltwater shrimp while 38% considered

prawns to be inferior to saltwater shrimp. About 13% reported that prawns were superior to saltwater shrimp.

An attempt was made to identify those factors which were associated with high consumer acceptability and willingness to reorder. Analyses of the consumer responses indicated that acceptability of the prawn entrees was significantly correlated with product ratings on appearance, taste, texture, and price. Therefore, acceptability of prawn entrees was dependent to a considerable extent on the characteristics of the entree and price. Also, it was observed that acceptability of prawns was not significantly correlated with the product form. Thus, entrees which included whole prawns could be as acceptable as those which consisted of only tails. Very low relationships between acceptability and consumer resident (in-state versus out-of-state) were observed.

CONCLUSIONS

Based on our preliminary results, it appears that locally produced prawns were successful in the market place and could command a share of the seafood restaurant trade. Depending on the entree, prawns could be marketed as tails or as whole animals. Further, apparent dissimilarities in preferences by restaurateurs and seafood retail markets might allow producers to market different portions of their crop to these two markets. It was also apparent that some restaurant managers and cooks were very sensitive to the consistency in count size and the convenience in the preparation of prawns. Thus, studies may be needed to identify suitable grading, processing, and packaging procedures.

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ECONOMIC ASSESSMENT OF A POTENTIAL SARDINE FISHERY IN THE NORTHERN GULF OF MEXICO

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INTRODUCTION

Prospects appear to be excellent for the development of a new Gulf of Mexico fishery based on Sardinella anchovia or Spanish sardines. This is one of the species of pelagic finfish which is generally considered to be underutilized. The fish have been harvested for a number of years for bait and fish food. A small amount has found its way into the human food market as fresh or frozen whole fish.

Spanish sardines have never been processed for human food on a commercial basis on the Gulf of Mexico. Limited research on preparation and canning of the fish was required because of the extensive literature and existing commercial methods for the preparation and canning of sardines in other areas. Specialists from the Food and Fiber Center of the Mississippi Cooperative Extension Service assisted Mississippi processors to refine preparation methods and transfer existing technology to the canning of Spanish sardines. Various recipes were tried and consumer taste tested until an acceptable recipe was selected.

Much of the recent effort has been developmental in nature. Existing commercial processors with an interest in product diversification became the primary participants in that process. This approach encouraged the processing of a product to meet the demands of an existing worldwide market for canned sardines.

Reactions to the canned Spanish sardines in the world market have been very positive. Reports are that the Gulf of Mexico fish are equal in quality to fish from other parts of the world. This may be an indication of their acceptability in the U.S. Consumer taste panel work done by the Cooperative Extension Service at Mississippi State University, indicated that the Gulf sardines compare favorably with canned domestic and imported sardines currently on the market.

MARKET POTENTIAL

There is a potentially large market for canned sardines from the Gulf of Mexico. The total U. S. consumption of canned sardines was 80 million pounds in 1979. Of this total, only 30 million pounds or 37 percent were produced domestically. Imports constitute the majority of sardines sold in this country, averaging nearly two-thirds of the total U. S. sardine supply. The average volume imported has consistently been about 50 million pounds annually for the past four years. Also, the total dollar value of imported sardines has

been considerably higher than the domestically produced sardines. Sardines from the Gulf of Mexico might be expected to achieve a market share equal to the current colume of domestic sardines.

Achieving such a market share would require about 30 million pounds of canned sardines annually or about 60 million pounds of fish on a round weight basis. In addition to the domestic market, a sizeable worldwide demand exists for canned sardines. Reliable estimates of worldwide supply or consumption of sardines are unavailable, but for the purposes of this paper it is assumed that an additional 30 million pounds of canned sardines or 60 million pounds of fish on a round weight basis could be exported. Africa offers a potential market for all types of U.S. fishery products including canned sardines. Thus, the total annual harvest of Spanish sardines required to serve both domestic and export markets could amount to 120 million pounds or 60 thousand tons annually. An annual harvest of that magnitude appears to be well within the established maximum sustainable harvest parameters.

ECONOMIC IMPACT OF THE RESOURCE

Commercial fishermen can produce Spanish sardines profitably for a price ranging from $160 to $200 per ton. At that price range, the ex-vessel value would be about $10.8 million annually. Based on National Marine Fisheries Service estimates of value added for all U.S. fishery products (Table 1), that catch would yield canned sardines with a retail value of about $37.7 million. The value added in the various stages of processing and marketing would be $26.9 million. The total impact of a $37.7 million fishery on the economy is not precisely known but should range from $75 to $113 million annually.[1]

TABLE 1. VALUE ADDED TO SEAFOOD PRODUCTS IN 1979

	Million Dollars	Percent of Retail Value
Domestic Landings	1,818	28.6
Marketing Margins		
Processor	713	11.2
Wholesale	936	14.7
Retail	2,885	45.4
Total Markup	4,534	71.4
Retail Value	6,352	

SARDINES PROCESSED IN MISSISSIPPI

During 1977 the staff of the Food and Fiber Center processed and canned three separate lots of Spanish sardines. The fish varied in length from four to six inches before dressing. All fish processed had

[1]This assumes a multiplier of two to three times the retail value of the fish.

been frozen after being caught. An established seafood canning plant on the Mississippi coast was used to process the fish. The fish were prepared according to well-established and time-tested procedures.

SARDINE CONSUMPTION IN THE UNITED STATES

The per capita consumption of sardines in the U.S. is quite low, averaging only 0.4 pounds per year over the past seven years (Table 2). Per capita consumption declined from a high of 0.5 pounds in 1973 to a low of 9.2 pounds in 1975. The 1979 figures showed per capita consumption of 0.3 pounds.

TABLE 2. PER CAPITA CONSUMPTION OF SARDINES

Year	Pounds per Capita
1970	.4
1971	.4
1972	.4
1973	.5
1974	.4
1975	.2
1976	.3
1977	.3
1978	.3
1979	.3

SARDINE HARVESTING

During the 1980 season, Spanish sardines were produced in three major areas of the east and nothern Gulf of Mexico. These areas were near Panama City, area I; Port St. Joe, area II; and Tampa-St. Petersburg, area III. There is no question that Spanish sardines can be harvested in commercial quantities in these areas during the times of year when the sardine fishermen ordinarily fish for them. The quantities harvested by fishermen in these areas do not necessarily reflect the total volume available because the fishermen fish for sardines for only a short period of time each year. Logs were maintained and returned from only one fisherman. The data aggregated from that fisherman showed that approximately nine tons of fish were taken per set and sets were made on an average of three miles from shore. Most of the sets were made in the morning, which may reflect that the fishing was done at the convenience of the fishermen rather than on a determination of the time when the fish were most accessible.

FISHING GEAR AND METHOD

Most of the Spanish sardines for bait have been produced using vessels, fishing gear, and fishing techniques adopted from other Gulf

fisheries. Purse seines with 1 to 1¼-inch mesh size have typically been used. The vessels utilized have been wood or fiberglass construction and are converted shrimp boats or other relatively small craft. The hole capacity for the vessels ranges from 10 to 40 tons.

It is typically a day fishery with the vessel leaving the dock early in the morning before daybreak and making sets on the schooled fish during the early to mid-morning and returning to the dock during the same day.

The most common method of preserving fish is icing.

Additional research and demonstration efforts are needed in catching, loading, preserving, and off-loading the fish. Fishing techniques are needed which will minimize the damage to the fish from the time they leave the sea until they reach the processing plant.

Existing fishing gear and technology should be closely scrutinized and alternative gear tested to determine the most efficient ways to fish. Drum seines have been proposed as an alternative to the purse seine which is the most commonly used net. The major difference between a drum seine and purse seine is that the drum seine is rolled onto a drum after it is pursed. This type of gear, used off the northwest U.S. coast, is claimed to be more efficient than the ordinary purse seine and may be effective for harvesting Spanish sardines.

Trawls are potentially efficient for harvesting the fish in deeper water. While hard scientific data are not available, it is thought that Spanish sardines may be available in deeper water during the times of the year when the inshore fishermen typically do not harvest them.

Preservation methods are also vitally important in providing a good high-quality product. Two at-sea preservation methods are being discussed as improvements over the icing method being used. One is termed the "champaign" system where a mixture of water and ice is placed in the hold and air is bubbled up through the mixture. Another method is chilled brine or seawater in the hold. Neither of these methods is new to the fishing industry. They have been proven in other areas of the country and for other species of fish. The effectiveness for preserving Spanish sardines remains to be determined.

SUMMARY

Considerable recent emphasis has been directed toward the potential for developing underutilized fish species from the Gulf of Mexico. There appears to be little opportunity to expand the landings of shellfish. However, future world food needs are expanding rapidly and require development of additional and fish resources. Greater dependence on the sea for food is a necessity for the next decade.

Coastal pelagics are thought to exist in volumes sufficient to support new fisheries in the northern Gulf of Mexico. Even though maximum sustainable harvest data are not available, many biologists feel that the resource is sufficient to support a sardine fishery in the area.

The U.S. domestic consumption of canned sardines is only about three-tenths pound per capita to a total of about 60 million pounds annually. During recent years only about one-half of the U.S. consumption

has been supplied from domestic sources. Sardines from the Gulf of Mexico would replace neither the domestic or imported sardines, but would most likely expand domestic consumption.

Foreign markets for canned sardines are large and expanding. South America, Africa and Europe provide market opportunities for Gulf sardines. The magnitude of that demand is not currently known.

New and expanded fisheries provide opportunities for increased employment and wealth generation to the economy of the northern Gulf. Each dollar spent exerts a multiplier effect on the economy of two to three times the initial expenditure.

CONCLUSION

It has become obvious over the past few years that a considerable potential exists for a sardine fishery in the northern Gulf of Mexico. There is no doubt that the species being considered, Sardinella anchovia, produces an excellent quality product which is highly acceptable to consumers. Processing methods are well-known for canned sardines and the Spanish sardine lends itself readily to these methods. The economics of processing and distribution of the canned fish is not expected to create any significant barriers to market development. With these characteristics the Spanish sardine is an excellent candidate for development.

There are, however, some unknowns about the Spanish sardine which may limit its development as a commercially acceptable species. At the top of the list are the biological questions of the relative abundance of fish and their seasonal availability. A successful canning industry requires an abundant supply of the raw material and that it be available throughout the year.

A sardine canning industry also requires a high quality raw product which will produce a consistently acceptable consumer product. Once the biological, harvesting and preservation questions are answered, there is a tremendous opportunity to develop a canned sardine industry on the Gulf of Mexico.

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DEVELOPING EXPORT MARKETS FOR GULF OF MEXICO AND SOUTH ATLANTIC SEAFOOD PRODUCTS

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INTRODUCTION

Development of export markets for seafoods produced from the Gulf and South Atlantic fishery regions is important for several reasons. Increased exports would help to offset the U. S. foreign trade deficit in fishery products and therefore improve the overall balance of payments. Increased export sales are consistent with the Fishery Conservation and Management Act and would lead to a fuller utilization of presently unutilized and underutilized species in the Gulf and South Atlantic region[1] of the U. S. A coordinated effort between government and the seafood industry, under the leadership of the Gulf and South Atlantic Fisheries Development Foundation, with primary funding from the Coastal Plains Regional Commission, has been underway for the past two years to develop foreign markets for Gulf and South Atlantic seafood products.

The objectives of this paper are to (1) review Southeast seafood export trade statistics, (2) discuss factors contributing to successful seafood export marketing programs, (3) review the export marketing strategy for the Southeast, (4) present the results of export activity surveys conducted during 1979-81, and (5) provide a preliminary evaluation of export market development activities over the last two years.

SEAFOOD EXPORTS AND DATA PROBLEMS

Exact estimates of the volume and values of exported Southeastern U. S. seafood products are difficult to derive due to the way export data are recorded and presented. Export data are recorded by the U. S. Customs district from which the product is exported. Seafood products landed in producing regions outside the Southeast are often shipped to the Southeast for export from Southeastern ports. These products become recorded as Southeastern exports. Examples are king crab, snow crab and salmon. Similarly, products landed in the Southeast may be shipped to the West Coast, Great Lakes region, or the Northeast for exporting. An example of an important Southeastern export product is mullet roe. Large volumes of mullet roe have been exported to Japan from the Southeast but recorded as exports from customs districts on the West Coast. Similarly, export sales to Canada are not recorded as exports from the Southeast, but rather from the customs district where the product departs the U. S.

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[1]The Gulf of Mexico and South Atlantic region referred to in this paper covers the coastal states from Virginia through Texas. This region is also referred to as the Southeast in this paper.

The large diversity of species in the Southeast presents another export data problem. Except for major species such as salmon, shrimp and king crab and for major product categories such as fillets, fish sticks and canned products, export shipments are not reported individually. Most Southeastern species are recorded in the "other" categories and are difficult to identify from published data sources. The following analysis is presented with these limitations in mind.

Based on published export statistics, total Southeast edible product exports amounted to 43.3 million pounds (19,633 metric tons) during 1979 with a value of $65.4 million (Table 1). This represents a 34 and 39 percent increase, respectively, over 1978. Exports such as mullet and ladyfish produced in the Southeast are probably included in the fresh and frozen whole or eviscerated "other", cured, or other fish and shellfish categories. These three categories totaled 14.2 million pounds (6,442 metric tons) of exports during 1979.

Shrimp was the most valuable export from the Southeast during 1979, followed by other shellfish, other whole or eviscerated fish, other fillets, whole or eviscerated salmon, canned shrimp, canned salmon and fish roe (Table 1). Edible product exports from the Southeast represented 7.8 percent of the volume and 6.4 percent of the value of U. S. edible exports during 1979. Export categories representing over 15 percent of the value of specific U. S. exports are canned sardines, shrimp, other fish and shell fish, fish sticks and portions, canned squid, other shellfish and canned shrimp.

REQUIREMENTS FOR SUCCESSFUL EXPORT MARKETING

Development of export markets requires particular attention be given to commodity and market characteristics. Those characteristics which contribute to successful export marketing depend on the type of market and commodity being exported. This discussion is only a brief overview of some of the more important characteristics which can foster successful exporting of seafood products. The characteristics discussed can be categorized into the four groups of (1) commodity characteristics, (2) market information, (3) business marketing practices, and (4) institutional support.

Commodity Characteristics

Fresh seafood products are highly perishable and therefore require special care and facilities in export trade. Developing markets for highly processed products tends to reduce potential problems relating to spoilage losses. Dependable means of rapid transportation with suitable preservation capabilities lessens the possibility of product loss. Product insurance further lessens the exporter's risk with perishable products.

A second characteristic of seafood products is the limited control producers have over annual supply and the highly seasonal nature of production. Storage is one means of reducing the impact of seasonal variations. This in turn requires inventory capital and firm market commitments to reduce risk and make inventory capital available at

Table 1. Exports of fishery product type for the United States and Southeastern United States, 1979.

Product Type	Pounds			Dollars		
	U.S.	Southeast U.S.	Percent of U.S. total	U.S.	Southeast U.S.	Percent of U.S. total
	thousands					
Edible fishery products:						
Fresh and frozen:						
Whole and eviserated:						
Salmon	140,160	777	.6	302,324	2,431	.8
Other	104,941	13,474	12.8	91,650	7,156	7.8
Fillets:						
Salmon	4,205	183	4.4	9,270	695	7.5
Other	46,559	3,016	6.5	35,720	2,952	8.3
Fish sticks and portions	896	279	31.1	1,453	357	24.6
Shellfish:						
Shrimp	28,934	12,095	11.1	87,392	36,061	41.3
King crab	36,219	55	.2	96,346	233	.2
Snow crab	42,978	26	.1	70,296	174	.3
Other	37,759	7,691	20.4	52,519	8,112	15.5
Canned fish and shellfish:						
Mackerel	8,357	605	7.2	11,142	791	7.1
Salmon	50,719	632	1.3	91,916	1,181	1.3
Sardines	1,590	1,120	70.4	1,180	729	61.8
Shrimp	5,469	697	12.7	12,391	1,854	15.0
King crab	866	49	5.7	3,898	270	6.9
Squid	8,382	1,522	18.2	2,447	484	19.8
Other	3,447	63	1.8	9,957	61	.6
Cured	10,441	394	3.8	15,326	397	2.6
Fish roe[b]	21,010	272	1.3	123,551	1,084	.9
Other fish and shellfish[b]	648	333	51.4	1,426	380	26.7
Total edible products	553,580[b]	43,282	7.8	1,020,204	65,402	6.4
Non-edible fishery products:						
Fish meal	31,402	20,792	66.2	5,526	4,254	77.0
Fish oils	198,497	188,629	95.0	39,571	36,928	93.3
Seal furs	a	--	--	2,450	--	0
Other	a	363	--	14,615	1,942	13.3
Total non-edible products	229,899[b]	209,784	91.3	62,162	43,124	69.4
Grand total	783,479[b]	253,067	32.3	1,082,366	108,526	10.0

[a]Not reported in pounds.

[b]Included in the same category in 1978.

Sources: (1) Southeastern totals derived from computer printouts of domestic trade (exports) by product type, importing country and U.S. customs district provided by the U.S. National Marine Fisheries Service, Washington, D.C.

(2) U.S. National Marine Fisheries Service. Fishery Statistics of the U.S., 1979. Current Fisheries Statistics No. 8000. U.S. Government Printing Office, Washington, D.C. April, 1980.

lower rates. The uncontrollable variation in annual supply often prevents export trade because either large quantity requests by buyers cannot be filled or economically efficient size shipments are not possible. Pooling arrangements among exporters may reduce the problem of limited supply.

Market Information

Certain types of market information are necessary for successful export trade adtivities. Species or product identification is necessary to communicate market prices and coordinate export supply with demand. Foreign consumers often desire products exporters have available but do not recognize the product because of differences in nomenclature. Seafood exporters should also be aware of foreign consumers' concept of quality. An established set of grades and standards will facilitate export trade providing they reflect foreign consumer tastes and preferences. Supplies and demands are more easily communicated with these items of market information. Foreign consumer tastes and preferences may be determined through reviews of trade statistics, market surveys, trade missions and trade shows.

Business Marketing Practices

Some of the major business marketing practices which are associated with high success levels in establishing export markets are market development, transportation, buyer-seller relations, packaging and financing. Success in these areas often depends on the size of the firm and the support facilities provided by the market system including industry associations and governmental bodies.

Large firms or groups of smaller export firms often engage in market promotion and development activities in order to identify and locate foreign buyers. These activities, in addition to discovering existing markets, often develop new markets and/or increase prices received. Associated with these market development activities should be the development of established or committed buyer-seller arrangements. Some of the more notable trade problems stem from delays in receiving payments for export shipments and a lack of firm commitments for export shipments. Without these assurances exporters take considerable risks and incur substantial interest and storage costs waiting for final trade transactions.

In order to fully take advantage of all trade possibilities, adequate transportation systems are a necessity. Ideally, transportation systems should provide access to all or most market areas with freight rates at levels that do not impair the nation's competitive advantage in foreign trade. Assembly of adequate volumes and establishment of large volume markets tend to lower freight rates. Vertical integration in the production and processing of seafoods facilitates assembly of larger volumes. Expecially important are transportation systems which protect highly perishable seafood products.

Another marketing practice important in export trade is packaging and labeling. U. S. exporters must be aware that the

metric system is used in most seafood importing countries. Packaging used in export trade usually must be more durable to stand up under more lengthy and difficult trips. At the same time, consumer or buyer appeal must be considered in choosing packaging materials.

A final factor to be considered is capital requirements and financing. The cost of international trade is often considerable. Efficient business practices tend to make financing more readily available. Governmental assurances are often necessary due to added risks in international trade.

Institutional Support

Institutional support facilitates international trade. Institutional support comes in the form of government programs, foundation activities and industry associations.

Group action is often needed to reduce tariffs, quotas and other trade barriers. Government action when necessary requires industry support or pressures. The same is true where domestic product standards enforced by government agencies are stronger than those required in importing countries or by competing exporting nations. Higher or stiffer standards tend to put domestic exporters at a comparative disadvantage.

In order to compete with many seafood exporting countries, U. S. exporters need more favorable financing arrangements. Many foreign competitors are wholly or partly financed by their government.

Market development programs sponsored by government agencies or industry groups are often necessary because of the size of many seafood exporters. The scale of operation is simply too small for many exporters to incur the tremendous expense of activities such as trade missions. Institutionally sponsored activities of this nature reduce the competitive advantage that competing exporters have when their governments provide these activities.

Considerable institutional support has been given to developing export markets for Southeastern seafood products since 1978. Principal support for export development has come from the Gulf and South Atlantic Fisheries Development Foundation, National Marine Fisheries Service and the Coastal Plains Regional Commission. Institutional support in the Southeast to develop export markets consisted of developing an export marketing strategy and sponsoring surveys of the industry in 1979 and 1980. Each of these are dicussed in the following sections.[1]

EXPORT MARKETING STRATEGY

The target marketing strategy for determining potential export markets for domestic seafood and in making buyer contacts in those areas has consisted of three components. These have been market personnel training, trade shows and trade missions.

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[1]Complete discussions and evaluation of the program may be found in (1) and (2).

Personnel Training

Most marketing personnel in the National Marine Fisheries Service, the universities and the various state market development agencies have been trained and are specialists in domestic seafood marketing. Very few had knowledge of the financial requirements, legal aspects, the "customs" and logistical problems (among others) associated with export market development. This knowledge was necessary for successful export-market development by the marketing specialists. Personnel training was a goal during the first year of the program.

Trade Shows

A trade show usually focuses on seafood, or various food commodities, and represents an atmosphere in which prospective buyers and sellers become acquainted. Product samples are normally presented to trade show audiences from a display booth manned by marketing personnel. This enables an on-site discussion of the attributes of the product and each participant is normally shown and/or presented potential supplier lists and information about the product such as seasonality, price ranges and other desired or requested product attributes. Trade shows are normally events scheduled regularly and represent a fairly low cost method for a large number of seafood suppliers from a region to contact a larger number of potential product buyers through representation by one to three marketing specialists.

Trade Missions

Trade missions, in contrast to trade shows, are normally accomplished by a delegation of industry and government representatives visiting a particular trade area or country with a particular mission or objective. This objective may consist of informing the country about the U. S. potential for seafood exports and for discovering the needs of that particular country regarding seafood products the U. S. is able to produce. Contacts are made with all industry segments in the country including shippers, marketing agents, consumers, etc. Contacts are also made with government representatives to discuss and inform the government of the intent of the trade mission and in order to fully understand the trading customs of the country or area.

Activities Since 1978

Since the latter part of 1978, industry representatives and marketing personnel have participated in seven trade missions and twelve trade shows in an effort to expand export demand for Southeastern seafood products. Reports were developed for these activities and information such as buyer lists were made available to seafood dealers. Trade missions were to Japan in 1978, Nigeria and Egypt in 1978 and 1980, and Venezuela, Hong Kong and Columbia in 1980. Trade shows were attended in Japan in 1978 and 1979, Germany in 1979 and Holland, Japan, South Korea, Venezuela, West Germany and France in 1980. U. S. trade shows also were attended.

These trips provided first hand experience for marketing personnel and company representatives. In addition, formal training was given marketing personnel. A seafood export workshop was sponsored by the Gulf and South Atlantic Fisheries Development Foundation in cooperation with the Florida Sea Grant Marine Advisory Program. The workshop was

attended by 48 participants representing agencies in nine states of the Southeast. The program focused on all aspects of seafood exporting. In addition, a large number of reference materials on exporting were distributed.

SURVEY OF SEAFOOD EXPORTERS

Two mail and telephone surveys were conducted with seafood dealers from Virginia to Texas to determine success levels and problem areas in seafood exporting. The first survey was sent in late 1979 to a selected list of seafood dealers and processors who were potential exporters of seafood products. The overall purpose was to identify exporters, problem areas and future program needs. A total of 21 firms indicated export involvement. Thirty-eight percent of the saefood dealers and processors responding to the first survey were involved in seafood exports. The second survey, conducted during late 1980 and early 1981, questioned firms thought to be exporters. Twenty-five questionnaires were completed from 34 mailed for a response rate of 71 percent. However, only 54 percent of the 25 firms were exporting during 1980.

Over $7.0 million in export sales was reported by firms responding to the survey covering the 1980 calendar year. Volume of sales reported was over 7.0 million pounds of seafood. Volume and sales information was collected by five 250,000 pound or dollar interval classes. Means of each pound or dollar size class were used for calculation. Firms indicating sales in excess of one million pounds or dollars were conservatively estimated at one million dollars or pounds.

Size of Exporting Firms

With one exception, exporting firms responding were either in the smallest or largest volume size classes. Forty-six percent had sales volumes of less than 250,000 pounds and an equal percent had sales volumes in excess of one million pounds. Size distribution of firms by sales value classes was slightly more widely distributed with firms reporting in all classes except the $500,000 to $750,000 class. The largest concentration of firms, 46 percent, was in the sales class of over $1.0 million.

Larger firms were more diversified. The larger the firm the greater the number of products exported and the greater the number of export countries. Firms with export volumes less than 250,000 pounds reported an average of 1.5 major export products while the largest firms reported an average of 5.7 products. Small firms who are directly exporting only export to one country or region while the largest firms average exporting to five countries or regions.

Distribution of Southeastern Seafood Exports

Taiwan was the most frequently reported export country in 1980, with 54 percent of the firms reporting exports (Table 2). The Caribbean and South America regions were the second and third most frequently noted areas with 46 and 38 percent of the exporters reporting these regions, respectively. Taiwan and the Caribbean areas were ranked first and third, respectively, in the 1979 survey. However, the implied importance of each country or region changes when export

distribution is based on volume exported. Egypt and the Caribbean and Middle East regions were the most important export markets with each accounting for 17 percent of the total volume exported. These three regions accounted for over one-half of Southeast seafood exports reported. Taiwan and Mexico were the fourth and fifth most important countries in 1980.

Table 2. Export distribution of Southeast fishery products by country, 1980

Country or Region	Exporters reporting shipments to country[a]	Volume shipped to specific country[b]
	percent	
Canada	15	3
Taiwan	54	10
Caribbean	46	17
South America	38	6
Mexico	8	9
West Germany	8	1
France	15	7
Nigeria	23	7
Egypt	23	17
Middle East	23	17
Japan	15	2
Other	15	3

[a]Percent of exporters reporting shipments to individual countries or regions does not add to 100 percent because most exporters ship to multiple countries.

[b]Percents refer to total pounds reported in the survey which were shipped to specified countries.

Major Seafoods Exported

Mullet was the most frequently exported species with 62 percent of all exporters and 100 percent of the large export firms exporting mullet (Table 3). Mullet roe was the second most frequently reported product by all firms while shrimp was the third most important. Fifty percent of the large firms exported mackerel and red drum and one-third of these firms exported ladyfish, jack crevalle, kingfish, shrimp and lobsters.

Table 3. Major seafood products exported from the Southeast, 1980

Seafood product	Percent of exporters reporting sales by weight		
	Total	Large firms[a]	Small firms[a]
Mullet	62	100	29
Mullet roe	46	67	29
Shrimp	31	33	29
Mackerel	23	50	0
Red Drum	23	50	0
Scallops	8	17	0
Monkfish	8	17	0
Squid	8	17	0
Butterfish	8	17	0
Ladyfish	15	33	0
Jack crevalle	15	33	0
Sardines	8	0	14
Porgy	8	0	14
King mackerel	15	33	0
Lobster	15	33	0
Blue fish	8	17	0
Oyster Stew	8	0	14
Black drum	8	17	0
Sheepshead	8	17	0

[a]Firm size based on total volume sales and not sales of individual species. Small firms are those with sales less than one million pounds.

Nineteen species and/or seafood products were reported as export commodities. This is a minimum estimate since most likely only major products were reported.

Export Market Outlets

Foreign distributors were the most important market outlet utilized by Southeastern seafood exporters. Fifty-four percent of the exporters shipped at least some of their exports to foreign distributors (Table 4). Fifty-one percent of total Southeastern exports moved through this market outlet. U. S. brokers were used by 38 percent of the exporters but only 10 percent of the export volume moved through this market channel. With the exception of foreign distributors, volume of exports was fairly evenly distributed among the remaining market buyers or outlets with between 8 to 12 percent of the Southeastern volume moving through each of the market outlets. "Other" market outlets were private outlets owned by Southeastern exporters.

Each firm with volume of exports equal to 250,000 pounds or less sold to only one type of export buyer. Firms with sales in excess of one million pounds used an average of 2.3 outlets.

Table 4. Distribution of market outlets and buyers utilized by Southeast seafood exporters, 1980

Market outlet or buyer	Percent of exporters reporting market buyer[a]	Percent of product moving through market
U. S. broker or dealer	38	10
Foreign import broker	31	12
Foreign distributor	54	51
Foreign retailers	8	8
Foreign government	23	9
Others	15	10

[a]Column does not add to 100 percent because many dealers use more than one market outlet of buyer.

Export Customs Districts

Seafood products from the Southeast were shipped through 15 customs districts throughout the U. S. (Table 5). Nine of these customs districts were outside of the Southeast region. Tampa was the most frequently used port with 54 percent of the firms reporting exports through this Customs District. Miami, New Orleans and Los Angeles were the second most important districts with each used by 31 percent of the exporters.

Table 5. Ports and U. S. customs districts through which Southeast seafood products were exported, 1980

Customs District	Percent exporters	Customs District	Percent exporters
South Atlantic:		Northeast:	
Norfolk	8	Philadelphia	8
Wilmington	8	Baltimore	8
Charleston	15	Buffalo	8
Savannah	23		
Miami	31	West Coast:	
Gulf of Mexico:		Los Angeles	31
		San Francisco	8
Tampa	54		
Mobile	15	Canadian Border:	
New Orleans	31		
Houston	8	Minneapolis	8

Savannah, Tampa, New Orleans, Buffalo, Los Angeles and Minneapolis were the only districts used by firms with less than $250,000 export sales. Firms with export sales in excess of $1.0 million shipped through 13 of the 15 districts with an average of 4.2 districts per firm. All large exporters shipped through Tampa and all but two shipped through Miami.

Export Marketing Problems

Export marketing problems can be grouped into two general categories. The first category is "functional" and contains those problems exporters encounter when actually exporting products. The other category is a "sales" category which contains problems exporters encounter which prevent them from exporting.

Functional.-- In five of the six problem areas noted in the surveys a smaller percentage of the exporters reported having problems in 1980 than in 1979 (Table 6). These problems are those associated with actual shipment. The most significant drop was from 55 percent to 15 percent with transportation problems. The only specific transportation problem mentioned by exporters was that often the shipments were late and this caused additional costs for the exporter when shipping firms are not required to bear the added costs.

Table 6. Percent of seafood exporters indicating specific export marketing problems, 1979 and 1980

Export problem area	Percent noting problem area	
	1979	1980
Transportation	55	15
Packaging	27	15
Market promotion and development	27	23
Locating and identifying buyers	27	23
Foreign consumer preferences	9	8
Financial arrangements with foreign buyers	0	31

Packaging problems were reported by 15 percent of the exporters in 1980 compared to 27 percent in 1979. The only specific problem noted was that U. S. boxes often would not meet export standards. This problem was noted in 1979. Exporters indicated that the adoption of the metric system reduced problems in the packaging area.

Market promotion and development was noted as a problem in 1980 by 23 percent of the firms compared to 27 percent in 1979. Some exporters felt that a greater variety of products should be promoted.

Locating and identifying foreign buyers was a problem for 23 percent in 1980 compared to 27 percent of the exporters in 1979. Problems noted were that it was too expensive an activity for an individual to undertake and that promotional efforts were often conducted during times of the year when exporters were unable to attend the trade shows or accompany the trade missions.

Most firms noted that they respected foreign consumer preferences with respect to size of package, product form and size and consequently had no problems in this area. One firm indicated a general lack of knowledge with respect to foreign consumer preferences.

Financial arrangements with foreign buyers was the most frequently reported problem in 1980 with 31 percent of the firms reporting this problem area. This was not reported to be a problem in 1979. Several reasons may exist for this difference. Overall tight credit markets, world unrest and general world-wide inflation may make it harder to reach acceptable financial arrangements. Most firms noted that they would not export unless lines of credit were established or they were paid in advance of shipment.

Sales.--Thirty-eight percent of the firms currently exporting reported they had requests for exports they could not fill in 1980 (Table 7). This compared with 91 percent of the firms in 1979. The two most important problems in both 1979 and 1980 were that the volume requested was higher than the production potential of the firm and that prices were too low. However, only 38 percent of the firms reported these problems in 1980 compared to 64 percent in 1979. Seasonality of production and a lack of transportation facilities to specific locations were the second most important group of problems in 1980.

Table 7. Percent of exporters having specified problems in meeting export sales requests, 1979 and 1980

Problems and problem areas	Percent of exporters having problems	
	1979	1980
Volume requested was higher than production potential	64	38
Price offered was too low	64	38
Did not produce the product requested	64	8
Production was too seasonal to meet requested shipments	45	23
Transportation problems:		
Volume too low for complete load	27	8
Correct kind not available	18	8
None available to destination	9	23
Lack of capital to get into export market	18	15
Lack of adequate insurance	9	0
Grades and standard too strict	9	15

Six of the eleven firms who responded to the survey but were not exporting had similar sales problems to those discussed above. Presumably if these problems could be overcome they would begin exporting. The remaining five firms had no interest in exporting.

SUMMARY AND EVALUATION

The export market development efforts initiated in late 1978 can only be given preliminary evaluation at this time. Published U. S. customs district export data for 1979 only became available in 1980. Total Southeast U. S. edible product exports amounted to 43.3 million pounds worth $65.4 million in 1979, up 34 and 39 percent, respectively, over 1978. Informal industry data indicate that 5.5 million pounds of "new" exports were sent to Africa from the Southeast in 1979.

Published export statistics for 1980 are necessary to fully evaluate the trade shows and trade missions. Export statistics for 1979 indicate growth in exports to countries where market development activities took place in 1979. This at least, indicates promotional efforts are correctly targeted to potential growth areas and early results appear to indicate that the marketing effort is probably causing export growth. Exporters indicated during the 1980-81 survey that contacts made through these activities had paid off or that they were presently being pursued. A product identification manual was developed noting available export species with descriptive information in four languages. In addition, a marketing opportunity newsletter was started.

Exporters reported fewer problems in the 1980-81 survey than in the 1979 survey in all five problem areas mentioned in both surveys. A new problem area reported in 1980 was making satisfactory financial arrangement with foreign buyers. This was the most frequently reported problem in 1980, with foreign buyers. This was the most frequently reported problem in 1980. Thirty-eight percent of the firms currently exporting reported they had export orders they could not fill in 1980. This compared to 91 percent in 1979.

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ECONOMICS OF SEAFOOD PROCESSING IN MISSISSIPPI

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INTRODUCTION

Seafood processing is a vital and economically important segment of the economy of Mississippi. The industry annually contributes about $100 million to the state's economy, and nearly 1,450 people were employed in the industry in 1978.

The entire seafood industry is estimated to contribute from $114 to $171 million to the state's economy annually. Mississippi's seafood processing volume and value greatly surpasses the state's relatively small share of seafood landings from the Gulf of Mexico. For example, in 1978, Mississippi firms processed about 16 percent of all shrimp harvested from the Gulf of Mexico while only 5 percent was landed in the state. (1, 2)

State processors concentrate primarily on shrimp, oysters and crabs. The most important segment of the industry is shrimp both in terms of processing plants and volume and value of product processed.

The industry has faced some severe problems during the past few years beginning with the devastation of Hurricane Camille and continuing through the marketing problems of the 1973 and 1974 seasons. In spite of these problems the industry has continued to play an important and expanding role in the U.S. seafood industry.

STRUCTURE OF THE INDUSTRY

The Mississippi seafood processing industry is made up of a relatively large number of firms ranging widely in size and volume of production. While there are an estimated 100 firms on Mississippi's coast, about 20 to 25 of them account for virtually all of the volume processed. Shrimp processors make up nearly half of the processors with oyster and crab processors accounting for most remaining plants. Finfish processors make up only a small proportion of the total.

Processing plants are typically privately owned and operated. Many of them are family businesses with the current operators often being second and third generations of the same family in the same business.

PROCESSORS SURVEY

Information contained in this paper was summarized from data provided by managers of processing plants on Mississippi's Gulf Coast. Personal interviews were conducted in the 23 largest

processing firms during late 1978 and early 1979. Analysis is based on the data obtained from these firms.

INDUSTRY PROBLEMS

Processors were asked to rank the most serious problems they face. Shortage of raw material was ranked as the most significant problem, followed closely by labor problems. Problems with labor arose because of a shortage of available and qualified workers and rising labor costs because of the higher minimum wage. Lack of sufficient freezer space for processed products was ranked third, with most processors having limited on-premises frozen storage space. Most utilize commercially available freezers. Commercial freezer capacity limitations, scheduling, and handling costs were perceived as impediments to expanding production. Commercial freezers in Mississippi were used most often with some product going into commercial freezers in Mobile and New Orleans.

Insufficient deep water was ranked as the fourth problem. Most processors off-loaded fewer boats at their own docks than they would have preferred. One reason for this is that the larger shrimp boats cannot navigate the shallow channels into Biloxi Bay where many processors are located. Docking more and larger boats would reduce the processor's dependence on trucked raw materials which now make up nearly 90 percent of the total volume processed.

Trucking charges add as much as $0.10 per pound to the total cost of the processor's raw materials. It would not be practical to furnish all the required raw material from boats docking at each processing plant. Some do not have docking facilities. Seasonality and geographical distribution of the shrimp harvest, for example, necessitates trucking of raw materials from points near where the fish are caught to Mississippi's processing plants.

Federal, state and local regulations and restrictions, as well as frequent changes in those regulations, were seen by processors as a factor limiting their growth. This seems to create an atmosphere of uncertainty which makes long-range planning more difficult.

Waste disposal was also mentioned by a number of processors as a serious and growing concern. Disposal requirements for screened waste are clearly established. Whether or not changes in regulations will occur to allow processors to return this waste to the Gulf is uncertain at this time. Solid waste disposal is becoming more difficult and more expensive. At some future time, processors may be forced to consider alternatives which will convert solid processing wastes into marketable products. Shrimp and crab wastes have a number of alternative uses which may become economically feasible as the costs of disposal and competing products become more expensive.

Changing regulations on fishing gear were seen by finfish processors as limiting current raw material availability as well as restricting future harvesting and processing of underutilized species which have economic potential.

Pollution of Mississippi's fertile oyster beds and changing

regulations on egg crabs were also seen as problems limiting the processor's raw material availability.

ECONOMIC VALUE OF THE INDUSTRY

Seafood processing is vital to the economic well-being of the state's coastal area. In spite of production, economic and weather problems, the economic contribution to industry has grown significantly in recent years. Prospects are good for future expansion. Growth will largely depend on marketing underutilized species.

In 1978, over 31 million pounds of seafood was processed in Mississippi firms. The total retail value of the processed seafood was $153 million. Value added by processing amounted to approximately $40 million. While only a small portion of the processed seafood was sold at retail in the state, processing created significant economic benefits. The total economic impact far exceeded the value added by the processors. Dollars paid out by processors as expenses for supplies, labor, utilities, and taxes are spent and respent creating additional business in the community. This is known as the multiplier concept and is estimated to range from two to three times the initial expenditure. Thus, the total impact of the seafood processing industry on Mississippi's economy in 1978 was from $114 million to $171 million depending on the magnitude of the multiplier.

Reported commercial landings of fish and shellfish in Mississippi in 1978 are shown in Table 1. The ex-vessel value was reported by National Marine Fisheries Service (3). The value per unit is calculated by dividing the total dollar value by the total pounds of product landed.

TABLE 1. REPORTED COMMERCIAL LANDINGS IN MISSISSIPPI IN 1978

	Landings	Total Value	Value per Unit
Shrimp (lbs.)	8,285,961	$9,296,944	$1.12
Oysters (lbs. meat)	682,430	735,059	1.07
Crabs (lbs.)	1,940,100	421,931	.22

Value added by the U.S. seafood marketing system, shown in Table 2, was taken from a National Marine Fisheries Service publication (3) and shows the value added at various stages in the marketing system. These relationships were used to determine the value added by Mississippi processors for the various types of seafood processed in the state in 1978.

The retail margin is relatively high, which results from the variation in firms and outlets through which seafood retail sales are made. Approximately 50 percent of retail sales are made through restaurants and other away-from-home outlets. Margins in that market are higher than in retail stores because of the service included in the food service industry.

TABLE 2. VALUE ADDED IN THE U.S. SEAFOOD MARKETING SYSTEM

	Proportion Percent	Value Mil. $
Fisherman's Share	23.2	$1,512
Processing Margin	26.2	1,703
Wholesale Margin	8.6	561
Retail Margin*	42.0	2,731
Total Retail Value	100.0	$6,507

*The high retail margin results from the fact that 50 percent of the processed shrimp in the U.S. is sold through the away-from-home market which normally carries a larger margin than products sold for house preparation.

Tables 3 through 5 show the margins for shrimp, oysters, and blue crabs by marketing segment. These margins were calculated from NMFS data in Table 2. Margins, cumulative values, and the retail price of each product were compared to the actual prices prevailing in 1978 and found to be within the existing market ranges.

TABLE 3. COMPUTED SHRIMP MARGINS, 1978

	Margin	Cumulative Price
	----------Dollars----------	
Fishermen's Share	1.12	
Processing Margin	1.27	2.39
Wholesale Margin	.42	2.81
Retail Margin	2.03	4.84
Retail Value	$4.84	

TABLE 4. COMPUTED OYSTER MARGINS, 1978

	Margin/lb	Cumulative Price	Margin/lb	Cumulative Price
	----------Dollars----------			
Fisherman's Share	1.07		8.56	
Processing Margin	1.21	2.28	9.68	18.24
Wholesale Margin	.40	2.68	3.20	21.44
Retail Margin	1.94	4.62	15.52	36.90
Retail Price	4.62		36.90	

TABLE 5. COMPUTED BLUE CRAB MARGINS, 1978

	Margin	Cumulative Price
	----------Dollars----------	
Fisherman's Share	.22	
Value of Meat (15% yield)	1.47	
Processing Margin	1.66	3.13
Wholesale Margin	.55	3.68
Retail Margin	2.66	6.34
Retail Price	6.34	

The estimated direct economic value of the various segments of the seafood industry in Mississippi is shown in Table 6. Values to fishermen were taken from the NMFS reported commercial landings reports (1). Processing values added were computed by applying processors' margins to the total volume of seafood products processed in 1978.

TABLE 6. ESTIMATED DIRECT ECONOMIC VALUE OF SELECTED SEAFOOD IN MISSISSIPPI, 1978

	Shrimp	Blue Crabs	Oysters
	----------Dollars----------		
Value to Fishermen	9,280,276	421,931	730,202
Processing Value Added	36,630,610	369,350	1,795,640
Wholesale and Retail Value Added	2,497,301	211,411	1,364,688
	48,408,187	1,002,692	3,890,530

Shrimp harvesting and processing generates more value for the economy of the state than does any other seafood product, with over $36.6 million in 1978. The retail value of that shrimp was about $140 million. Not all of the wholesale and retail margins on the processed shrimp were retained in Mississippi because of the large proportion of shrimp sold outside the state.

The estimated total economic impact of the seafood processing industry on the economy of the state in 1978 is shown in Table 7. Processing value added amounted to $41 million, with shrimp processing 89 percent of the total. Processing and sales volume included the value of reported commercial landings and margins on wholesale and retail sales made in Mississippi. Estimates of the total economic contribution of the shrimp industry varied from nearly $97 million to over $145 million. Oysters, finfish and crab processors made a less significant but important contribution to the state's economy.

TABLE 7. ESTIMATED TOTAL IMPACT OF THE MISSISSIPPI SEAFOOD PROCESSING INDUSTRY ON THE ECONOMY OF THE STATE

	Value Added	Landings, Processing and Sales	Estimated* Total Economic Impact Range
	----------Million Dollars----------		
Shrimp	26.6	48.4	96.8 - 145.2
Oysters	1.8	3.9	7.8 - 11.7
Crabs	.4	1.0	2.0 - 3.0
Finfish**	2.2	3.7	7.4 - 11.1
Total	41.0	57.0	114.0 - 171.0

*Based on a multiplier range of 2 to 3. This means that each dollar generated in the seafood industry would generate two to three dollars of additional spending in the economy.

**Only two firms were primarily finfish processors. Detailed information was not presented which might violate the confidentiality of data provided by those firms.

Estimates of the total economic impact of the seafood industry varied from $114 million to $171 million in 1978. Fish produced and processed for pet food and industrial purposes added additional millions of dollars to the economy but were not included.

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TORRY METER READINGS VERSUS SUBJECTIVE EVALUATIONS OF FIVE GULF COAST FINFISH

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Freshness of fish is traditionally assessed by sensory methods using the senses of sight, smell and touch. This method makes it difficult to establish standards that can be applied in different locations and by different assessors. For this reason, the torry meter was designed to fulfill a need for objective methods for measuring freshness that do not depend on the subjective opinion of human judges. Species of fish in the original research, as the torry meter was being developed, did not include those in the Texas Gulf Coast area. For practical application in this area, standard ratings were needed for traditional Gulf Coast finfish.

The torry meter is a hand-held, portable instrument designed to indicate freshness of fish. An alternating current is passed through the fish between the outer pair of electrodes and the voltage sensed by the inner pair. An electronic conversion takes place and a score of 0-16 is registered on a digital display window. To operate the torry meter, the mode switch is first turned to "1" or "16". The "16" is for averaging a batch of fish and "1" is for research which was used in this project. The base of the instrument is firmly placed on the fish so that it lies parallel to the lateral line in a thick, fleshy part. The "read button" is pressed and released while the instrument is held in place until a reading is made.

Five 1½-pound fish were selected and monitored for 12 days: trout, red drum, black drum, sheepshead and flounder. On the first day, the fish were read alive and at their natural body temperature. The fish at the second reading were gutted and chilled (Table 1).

Table 1. Torry Meter Readings for Five Fish, Alive and After One Day

Fish	Alive Just Caught	Chilled ≤ One Day Old
Trout	14	14
Red Drum	14	13
Black Drum	10	12
Sheepshead	13	16
Flounder	15	14

The progression of each fish is indicated in Figures 1-5.

RESULTS

Of the five fish tested, flounder had the highest temperature reading and trout the lowest at the end of the testing period. Meter

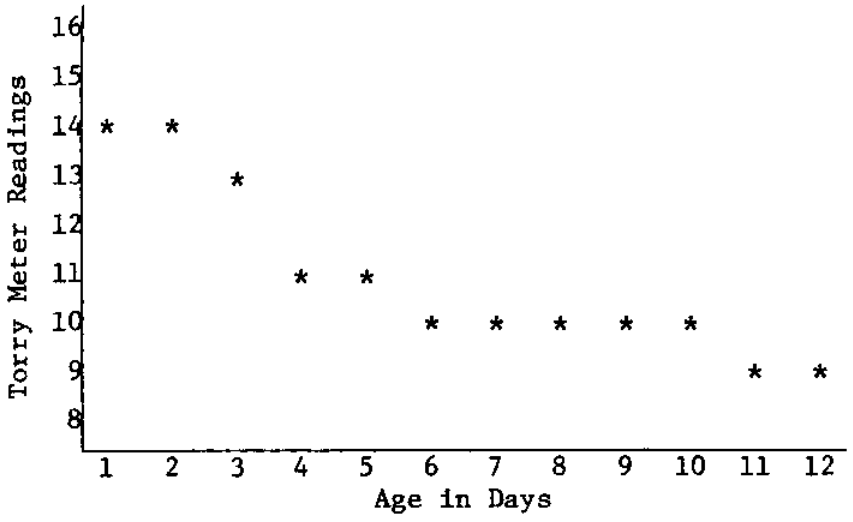

FIGURE 1: TROUT

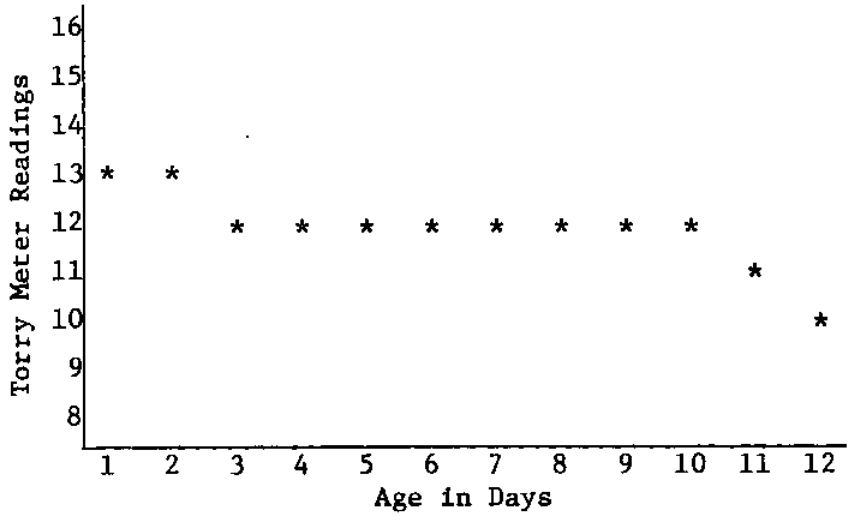

FIGURE 2: RED DRUM

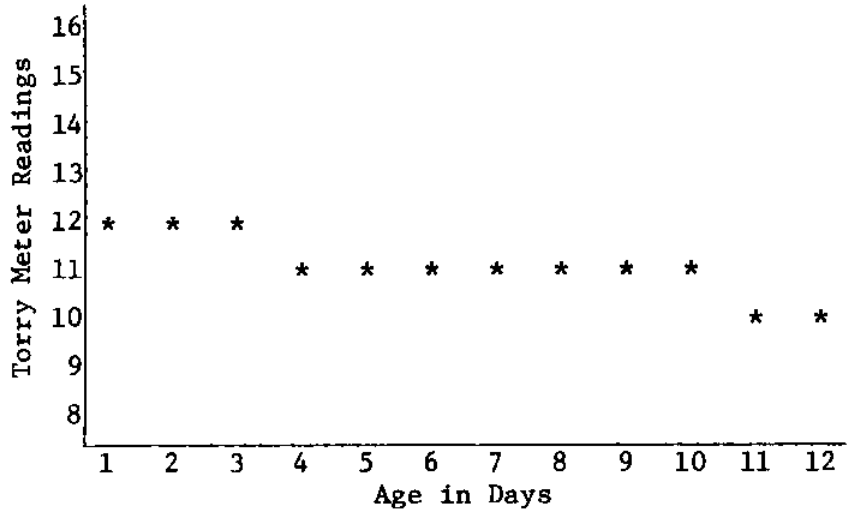

FIGURE 3: BLACK DRUM

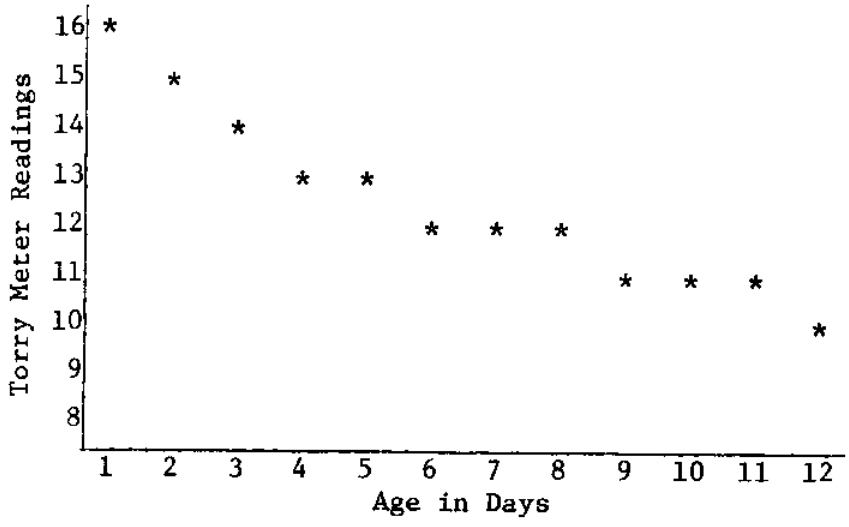

FIGURE 4: SHEEPSHEAD

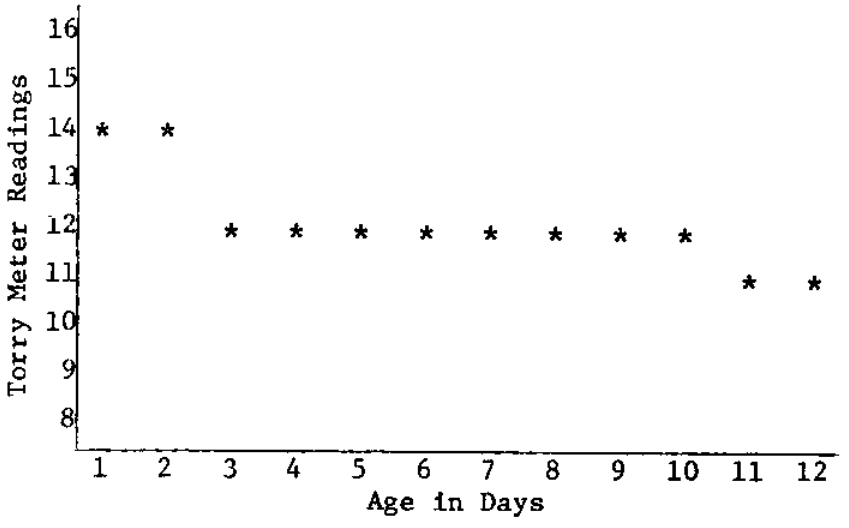

FIGURE 5: FLOUNDER

readings of the fish were not taken after the twelfth day on ice, as sensory evaluations were so low the fish were judged unpalatable. The first obvious deterioration in quality was evident on the fourth day: trout at a reading of 11, red drum at 12, black drum at 11, sheepshead 13, and flounder 12. Even though the torry score remained constant for several consecutive days on each fish, obvious signs of quality loss were noticed. Trout and black drum began to show deterioration at a lower meter reading first, and they also had the lowest scores at the end of the twelfth day. Trout ranged from 14-9 in 12 days; red drum 13-10; black drum, 12-10; sheepshead, 16-10; and flounder, 14-11.

CONCLUSIONS

The meter was intended to measure certain properties of fish muscle and skin that change in a systematic way during storage in the wet state. Between the measuring electrodes are two auxiliary electrodes. In normal operation, one is substituted out. The other

acts as a temperature sensor to determine whether there is proper contact with the fish. One of the auxiliary electrodes contains a thermistor which measures the fish temperature and automatically corrects the reading. This was true in about half of the experiments conducted on Gulf fish. The accuracy of the initial quality determination is affected by temperature, fat content, mishandling and delayed icing, and season of the year due to the spawning cycle and availability of food. Temperature proved to be the most obvious factor in evaluating freshness with the torry meter. A reading of "12" may be a freshly caught fish promptly chilled (only 2 hours out of the water). So, 12-16 may be an impossible torry meter score for some species of fish at their peak of freshness. Delayed icing usually causes lower meter readings during storage in ice than fish iced immediately after catching. A reading is always 0-3 after freezing, regardless of the quality before freezing. Freezing has a drastic effect on cellular constituents of muscle. Any process that affects the structure of the muscle at the cellular level will also affect the measurements almost invariably to lower them. Variations in scores are due to expressions of the variability of biological organisms.

SUMMARY

Torry meter readings are not direct measures of freshness as defined in sensory terms but are strongly related to it. "Days in ice" is not necessarily a good measure of freshness unless it is related to the environmental factors. A batch of fish caught at the same time and handled and stored identically will spoil at different rates because of variation in chemical and bacterial activity. It is difficult to assign a torry meter score to a particular species of fish as a reference for consumer satisfaction. We have found greatest use for the meter in determining fresh from frozen. In my experience, fish that has been frozen always rates 0-3 on the meter.

THE EFFECT OF WATER, BISULFITE AND HYPOCHLORITE RINSES ON THE MICROBIAL FLORA OF SHRIMP

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INTRODUCTION

Both bisulfite and hypochlorite solutions are widely used in the shrimp industry. Bisulfite dips have been shown to be an effective means of controlling black spot (4,5), an enzymatic darkening of the shell. The recommended level is a 1.25% solution used as a dip for 1 min. Hypochlorite solutions are used as sanitizing agents throughout the food industry and have been found to be highly effective when used properly. Levels of usage within the seafood industry for product contact generally are in the range of 10-20 ppm (8,9), whereas use levels within the meat industry for carcass decontatmination may be in the range of 200-450 ppm (3).

The actual control of microorganisms by these two compounds is not fully understood. At the recommended use level, bisulfite is not considered to affect microbial populations (4,5); however, at higher levels it has been shown to retard growth of spoilage organisms (4). Available data on hypochlorite usage is also limited, although it is widely used in the shrimp industry. Both compounds are subjected to abuse and it is difficult to determine what concentrations are actually used in the industry.

Previous studies in this laboratory (10) had indicated that there appeared to be a synergistic antimicrobial effect between bisulfite and hypochlorite when used on shrimp. This study was initiated to more fully understand what antimicrobial action could be expected from these two compounds when used at various concentrations.

MATERIALS AND METHODS

Fresh Penaeus shrimp were obtained from the west coast of Florida and were immediately iced and brought to the laboratory in Gainesville. Samples were removed as needed for experiments for up to two days. The remainder was then frozen for subsequent examination. Frozen samples were thawed overnight at 5°C and analyzed.

Standard microbiological procedures (1) were used with incubation of aerobic plate counts at 20°C for five days.

Reagent grade sodium bisulfite was used in this study. Granular calcium hypochlorite (HTH, Olin Corp.) was the source of available chlorine. Hypochlorite solutions were adjusted to pH 6.5 before use. Residual chlorine determinations were by standard procedures (2). All solutions were tempered to 20°C before use.

Following preparation of the rinses, shrimp were placed in the dip solution (1 part shrimp to 10 parts dip) for 15 min and stirred every 5 min for a period of 1 min. The shrimp were then removed, dilutions prepared and plated. The final pH and residual chlorine in the dips were then determined. In studies in which the shrimp were subjected to two rinses, the shrimp were removed from the first rinse, placed in Whirl-Pak bags and stored at 5°C for one hour. They were then removed from the refrigerator, placed in the second dip for the 15 min period and then analyzed. For the long-term iced storage studies, concentrations of 1.25% bisulfite and 100 ppm hypochlorite were used. Equal quantitites of shrimp were rinsed in either tap water or bisulfite for 5 min, packed in ice and stored for up to 72 hr. Samples were removed at 24-hour intervals, rinsed in either tap water or hypochlorite solutions, and analyzed.

All results are the average of three studies.

RESULTS AND DISCUSSION

In that results of a study of this kind are extremely relative, only trends will be discussed. It would be unrealistic to discuss data of this nature in specific terms because of the marked differences in the way shrimp are harvested, handled and treated prior to any microbial analysis. However, these data give an indication of the efficacy of the various treatments as defined in this study.

One of the most interesting results of this study was the reduction in microbial load due to a tap water rinse. Although the tap water is chlorinated at about 1 ppm, microbial removal must be mechanical and indicative of the ease with which the surface organisms may be rinsed away. How fluming of shrimp or the use of additional wash tanks might effect a given microbial load would need to be evaluated on an individual plant basis. One obvious shortcoming to the use of excessive water within a plant is the problem of discharges. The most logical place for this washing to occur is aboard the trawler, and this fact has been demonstrated previously (7).

Although the literature (4,6) is not always clear as to the effect of bisulfite dips in reducing the microbial load on shrimp, our data definitely showed a reduction (Table 1). This is in agreement with the generally accepted usage levels of various sulfites in the food industry. All treatments, regardless of the concentration, reduced the microbial load to less than that of the water rinses. It is quite probable that this reduction is due to the reduced pH of the bisulfite solution, in that even at the lowest concentration tested, reduction occurred. The pH varied from 5.2 at a concentration of 0.15% to 4.4 at a concentration of 2.5%.

Table 1. Effect of bisulfite rinses on the microbial flora of shrimp (avg. of 3 studies).

Treatment	Org/g	% Reduction
None	2.36×10^5	
Tap water	1.80×10^5	24
0.15% bisulfite	1.70×10^5	28
0.30% bisulfite	1.60×10^5	32
0.60% bisulfite	1.37×10^5	42
None	1.90×10^5	
Tap water	1.08×10^5	43
0.6% bisulfite	9.68×10^4	49
1.25% bisulfite	6.37×10^4	66
2.50% bisulfite	4.95×10^4	74

Hypochlorite rinses were effective as expected (Table 2). However, destruction of all microorganisms was not possible even at 200 ppm. This can probably be attributed to a number of factors, e.g., the buffering effect of shrimp protein, organisms in the gut and insufficient contact time. Final pH values of the hypochlorite solutions ranged from 6.5 to 5.0, the lowest value occurring with the 200 ppm hypochlorite solution. This lowering of the pH by hypochlorite rinse solutions was attributed to the formation of hydrochloric acid during the breakdown of the hypochlorous acid.

Table 2. Effect of hypochlorite rinses on the microbial flora of shrimp (avg. of 3 studies).

Treatment	Org/g	% Reduction
None	2.36×10^5	
Tap water	1.80×10^5	24
12.5 ppm	1.32×10^5	44
25.0 ppm	1.32×10^5	44
50.0 ppm	1.23×10^5	48
None	1.90×10^5	
Tap water	1.08×10^5	43
50.0 ppm	4.40×10^4	78
100.0 ppm	3.33×10^4	82
200.0 ppm	2.68×10^4	86

Results from studies using sequential rinses of bisulfite and hypochlorite are presented in Table 3. The data show the increased effect that a prior bisulfite rinse had on the action of hypochlorous acid. This effect was consistent and was attributed to the reduced pH on the shrimp surface, resulting in an increase in the reactivity of the hypochlorous acid. Unfortunately, the enhancement of bactericidal action did not extend through 24 hrs of iced storage of the bisulfite dipped shrimp (data not shown) and no attempt was made to determine the length of the increased activity. However, further work

may indicate that a procedure can be developed to capitalize on this increased action of hypochlorite by using a combined treatment rather than on the action of hypochlorous acid alone.

Table 3. A comparison of two sequential rinses, hypochlorite to bisulfite vs. bisulfite to hypochlorite, holding the hypochlorite concentration at 50 ppm.

Treatment (org/g)		
Bisulfite Concentration	Hypochlorite to Bisulfite	Bisulfite to Hypochlorite
0.15	87×10^3	73×10^3
0.30	57×10^3	20×10^3
0.60	40×10^3	23×10^3
1.25	46×10^3	42×10^3
2.50	47×10^3	35×10^3
Average	55×10^3	39×10^3

Residual chlorine determinations for the sequential rinses are shown in Table 4 and were somewhat unexpected. The extreme reactivity of hypochlorous acid in the presence of organic matter is well documented; however, for most of the combinations studied, there was some hypochlorite remaining after the 15 min dip. Chances in pH (Table 4) in the rinses were also quite marked, particularly in the sequential rinses where high concentrations of bisulfite and hypochlorite were used.

Table 4. Final pH and residual chlorine concentrations in the hypochlorite solutions used as the second sequential rinse.

1st Rinse	2nd Rinse: Hypochlorite				
Bisulfite	12.5 ppm	25 ppm	50 ppm	100 ppm	200 ppm
0.15%	4 (6.2)[a]	12 (6.1)	25 (5.8)		
0.30%	0 (6.2)	9 (6.0)	20 (6.0)		
0.60%	0 (6.3)	0 (5.7)	12 (4.6)	34 (4.1)	97 (3.6)
1.25%			4 (3.8)	21 (3.3)	80 (3.2)
2.50%			0 (3.8)	0 (3.2)	50 (2.8)

a = (pH)

These data, while pointing out the efficacy of various rinse treatments, do show that the complete reduction of the microbial load on shrimp by hypochlorite is not possible, and therefore, this practice should not be relied upon as a decontamination procedure for organisms of public health significance. Microbial quality must be maintained from the moment of actch, and attempts at improving it by chemical means probably will not be effective.

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RAPID METHOD FOR DETERMINING SHRIMP DECOMPOSITION

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INTRODUCTION

There have been several tests developed to measure physical and/or chemical changes in flesh, which parallel development of deterioration. However, the majority of these tests are very tedious as well as time consuming as they require the isolation and separation of components which, in turn, lead to formation of artifacts or loss of volatiles.

Deterioration of seafood quality has mainly resulted from tissue enzyme action or enzyme action of inherent or contaminating organisms. The spoilage action in seafood products has mainly been attributed to bacterial action and the subsequent formation of compounds producing off odors, colors and flavors (Fieger et al. 13, 14).

The ideal test for determining shrimp quality would be one which is rapid, simple and reliable and which would measure a compound or compounds which change in the shrimp simultaneously with decomposition.

A simple, rapid and very sensitive technique for analyzing volatiles by direct gas chromotography was developed by Dupuy et al. (10). Further application of the technique was applied to such diverse products as peanuts, cabbage, grapefruit rind, tobacco and meats, besides the volatiles in vegetable oil (Brown et al. 3).

This study was undertaken to assess the feasibility of utilizing this rapid gas chromatographic technique as a direct, rapid, sensitive method of measuring quantitatively trimethylamine, an indicator of decomposition in shrimp. In addition, a scanning election microscope was used to determine its value in detecting and correlating chemical with morphological changes occurring as a result of shrimp decomposition.

METHODS AND MATERIALS

Shrimp samples were obtained from a large seafood processing plant located in Tampa, Florida. Of the six samples obtained, three were fresh green headless shrimp on the breading processing line and included fresh green headless unpeeled shrimp just ready for processing, fresh green headless peeled shrimp and fresh green

headless peeled and breaded shrimp. The other samples included fresh green headless peeled shrimp treated with sodium tripolyphosphate ($Na_5P_3O_{10}$), a sample of green headless shrimp at the earliest point of sensory detectable spoilage and a sample of green headless shrimp in an advanced stage of decomposition as judged by the company's trained taste panel. The final sample was of local shrimp forzen immediately upon removal from the net.

Gas Chromatographic Analysis

The procedure utilized was that developed by Dupuy et al. (10) which is based upon the in situ vaporization of volatiles from the samples which have been inserted directly into the gas chromatograph's injection port.

Samples of shrimp were prepared in the following manner for analysis in the gas chromatograph. Approximately 200 mg slices were prepared from each sample and placed in a 3 3/8-inch length of 3/8-inch OD borosilicate glass tubing and packed on both sides with a plug of volatile-free glass wool. Also, 200 mg of K_2CO_3 was placed in each glass tube before plugging to trap any volatile acids produced and to retain water.

A Tracto MT-220 gas chromatograph with dual independent hydrogen flame detectors, a Westronic MT 22 recorder and a Hewlett Packard Intergrator model 3370B was used for the analyses. Columns were stainless steel U-tubes, 1/8 inch OD, 6 feet long and packed with Porapak Q. The carrier gas used was nitrogen at 50 ml/min in each column; hydrogen 25 ml/min to each flame; air 1.2 cu ft/hr for both flames. The inlet temperature was 120°C. The column was programed between 30° and 200°C with an initial hold at 30°C for 10 minutes followed by a program at 4°C/min for 35 min. A final hold was at 200°C for 30 min. The attenuation was set at $2x10^{10}$ and the chart speed was 15 in/hr.

Scanning Electron Microscope Analysis

Shrimp pieces were cut from each sample and placed in FAA (10% formalin, 85% ethanol, 5% glacial acetic acid). Slices from these pieces from the samples used were prepared for the scanning electron microscope (SEM) by washing in distilled water, dehydration in 2,2 dimethoxy propane (Johnson et al. 16) and critical point drying. Dry specimens were mounted on aluminum stubs with aluminum paint and spattercoated with 200 A° gold-palladium. Photographs were taken at a magnification of 800x and 4000x with a Hitachi S-500 scanning electron microscope operating at 25KV.

RESULTS AND DISCUSSION

Tests for trimethylamine (TMA), volatile acids, bacterial counts, sulfhydril groups and ammonia as reported by Bailey et al. (1) is useful for determining the onset of shrimp spoilage. Although individual tests were not necessarily conclusive in objectively rating shrimp, they are in various combinations relative quality indices. A TMA value of 6.3 mg/100g of headless, unshelled shrimp appears to be an index of unacceptable shrimp.

Other useful test suggested for quality indices for shrimp include pH, amino-nitrogen, B-vitamin, total volatile nitrogen/amino acid-nitrogen, volatile reducing substance hypoxanthine, etc. (4, 5, 6, 7, 8, 9, 11, 15, 16, 17, 18).

Table 1 presents the TMA values detected in the seven samples of shrimp analyzed by the gas chromatographic technique. The trimethylamine (TMA) detected in the samples ranged from a low of 0.2 mg/100 g shrimp found in the fresh local shrimp to a high of 16.3 mg/100 g of a completely decomposed shrimp sample. It appears that index TMA value of 6.3 mg/100 g appears in the earliest stage of sensory detectable spoilage.

Table 1. Analysis of Decomposition in Shrimp

Sample	Trimethylamine (mg/100g)
Fresh local shrimp	0.2
Fresh green headless processed shrimp	0.6
Fresh green headless processed shrimp - peeled	1.3
Fresh green headless processed shrimp - breaded	0.5
Fresh green headless processed shrimp - $Na_5P_3O_{10}$	0.6
Green headless shrimp - earliest sensory detection of spoilage	6.6
Green headless shrimp - Advanced Decomposition	16.3

Generally, the appearance of TMA in fresh unspoiled shrimp is in contrast to results reported by Fieger and Friloux (14), Bailey et al. (1) and Betha and Ambrose (2). They determined by the Dyer (11) method that the presence of TMA occurred only after off odors and spoilage were detected.

Figures 1, 2 and 3 were gas chromatograms which indicated the increase of trimethylamine concentration as the quality of the shrimp varied from an excellent fresh sample, an early estage of decomposition and finally a completely decomposed sample with values of 0.2/mg/100g, 6.6 mg/100g, and 16.3 mg/100 g respectively.

Gas chromatograms of samples from the processing line as the fresh green headless samples passed along the line to the stage of fresh, green headless peeled and breaded shrimp samples can be seen in Figures 4, 5 and 6. These relatively low TMA values were not unexpected as a relatively short period elasped between the three points of sampling and very little decomposition was expected. Generally, less than 20 min would elapse between these three points and all samples would be processed and in the freezer within an 8-hr shift period.

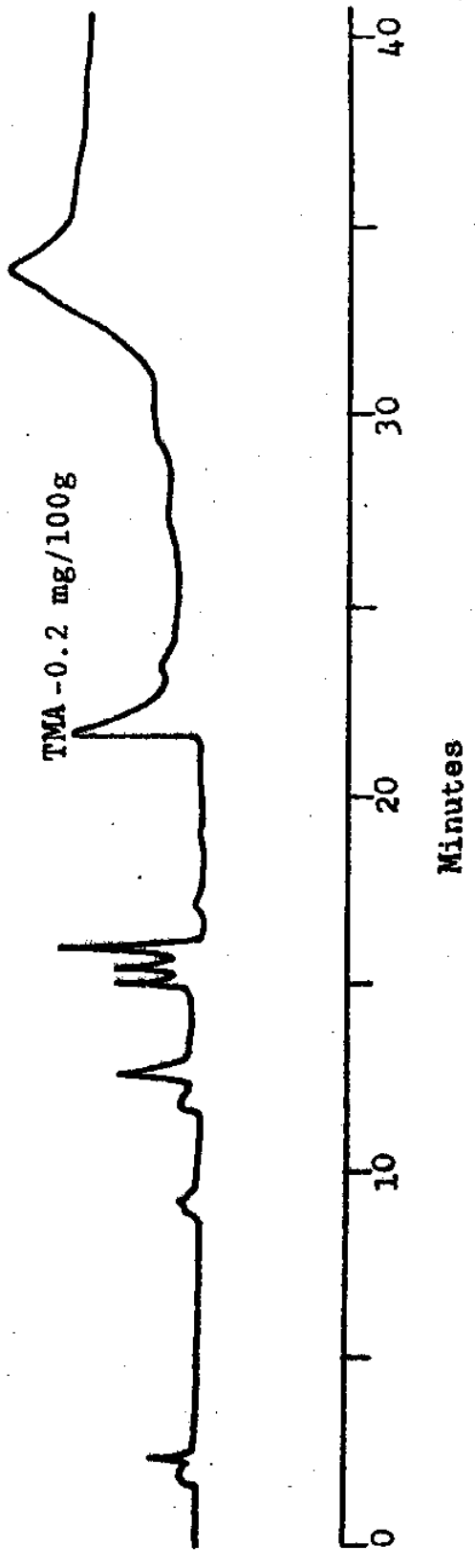

FIGURE 1. Gas chromatogram of fresh local shrimp.

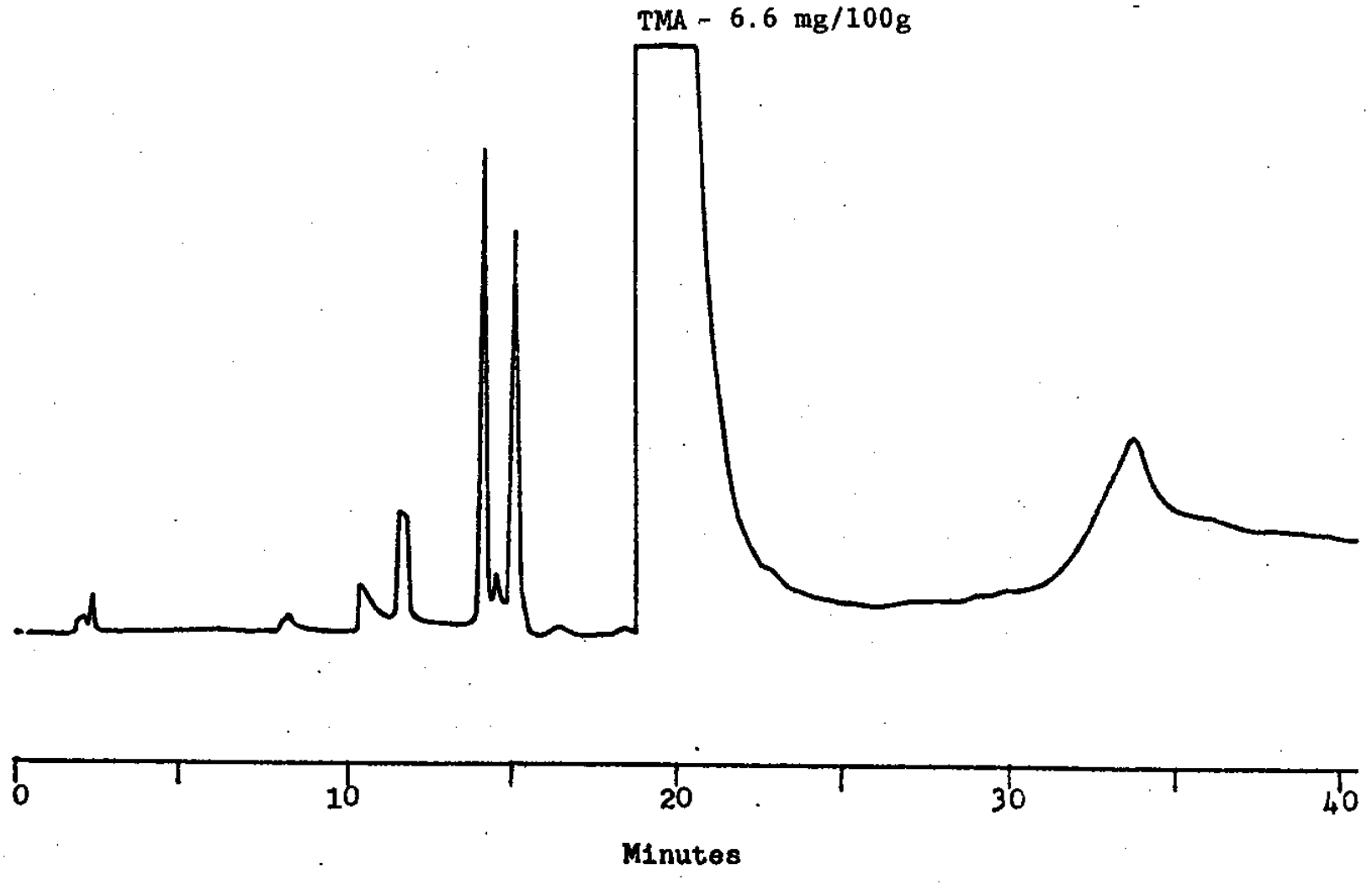

FIGURE 2. Gas chromatogram of green headless shrimp - earliest organoleptic detection of spoilage.

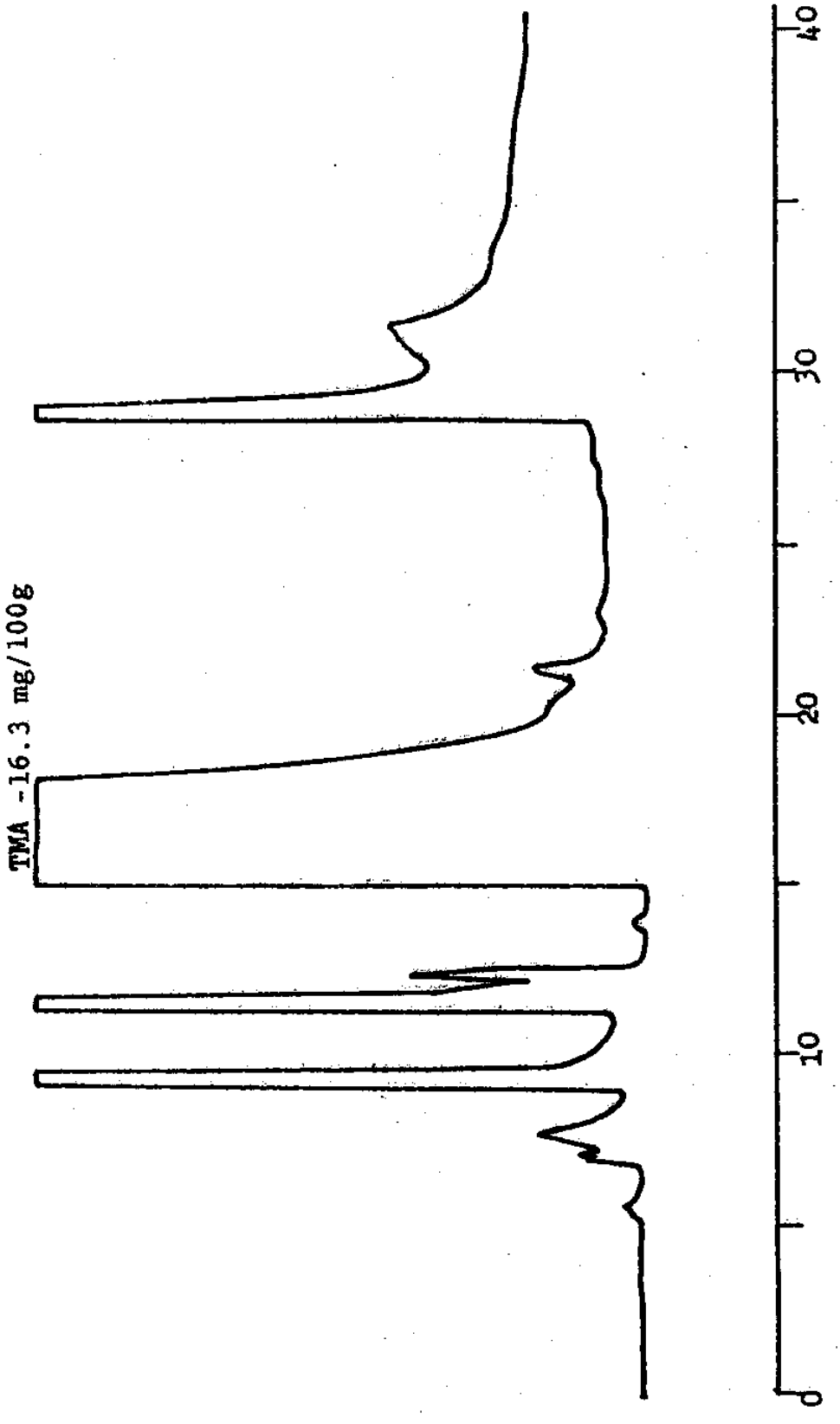

FIGURE 3. Gas chromatogram of green headless shrimp - completely decomposed.

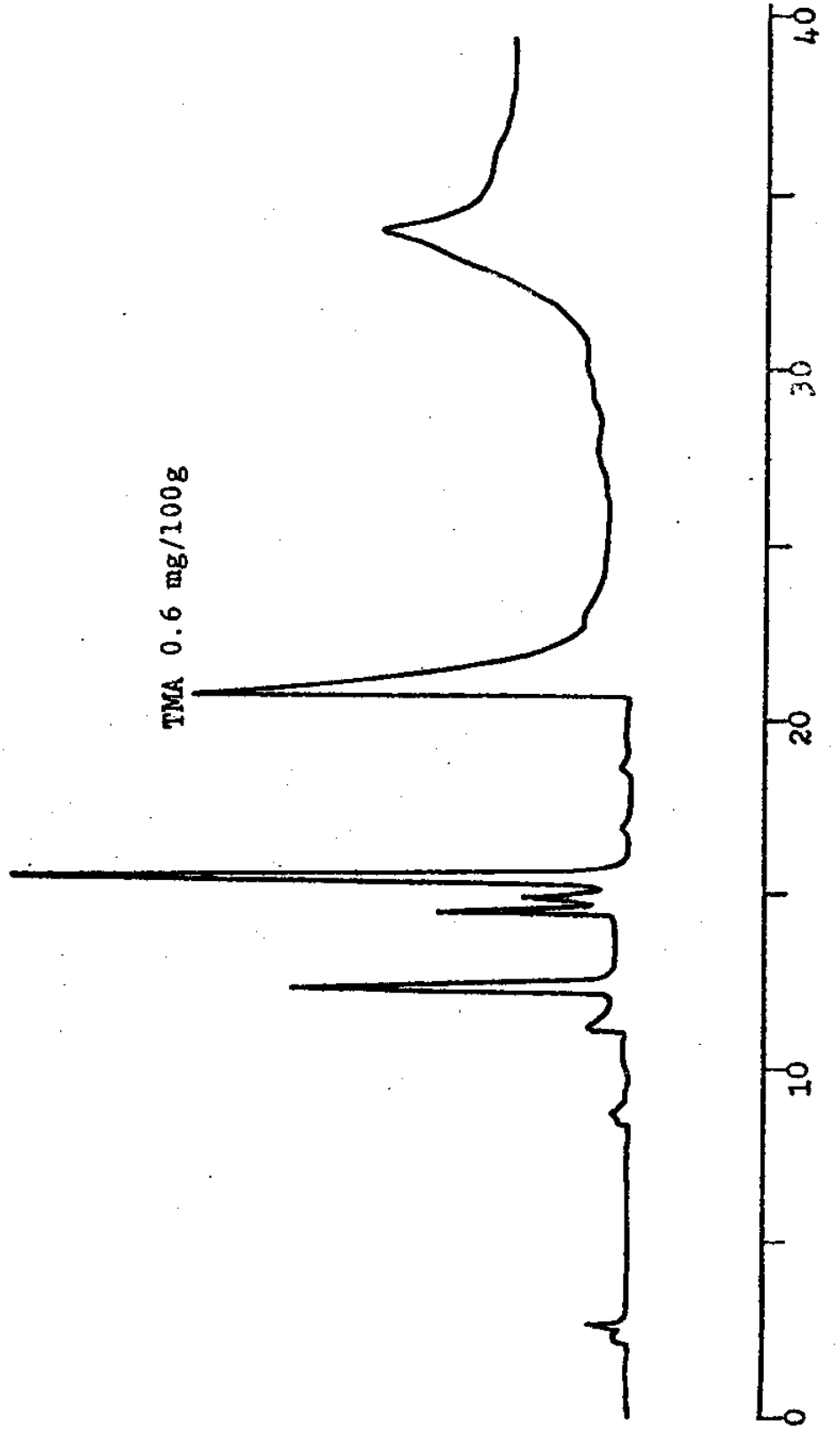

FIGURE 4. Gas chromatogram of fresh green headless processed shrimp.

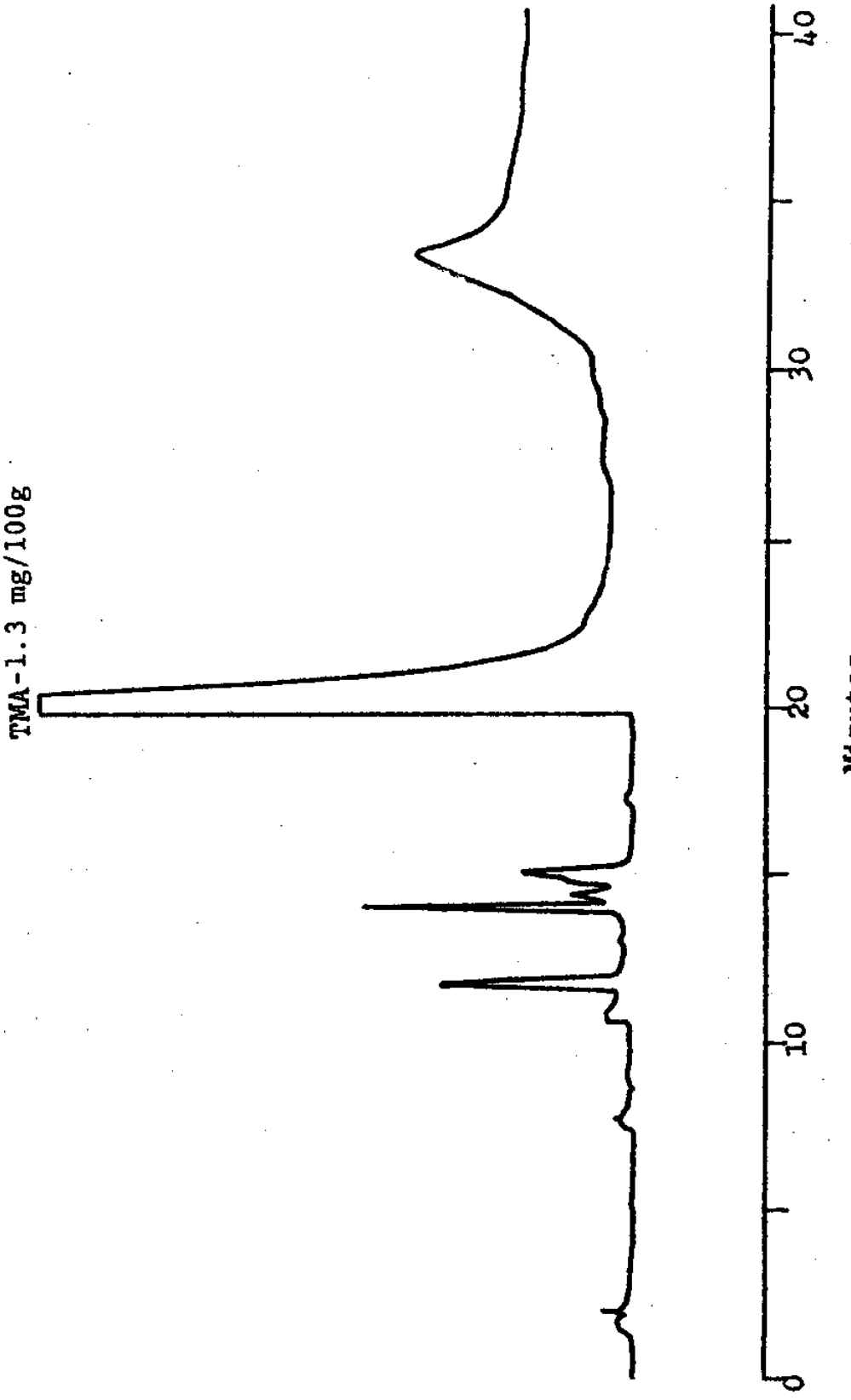

FIGURE 5. Gas chromatogram of fresh green headless processed shrimp - peeled.

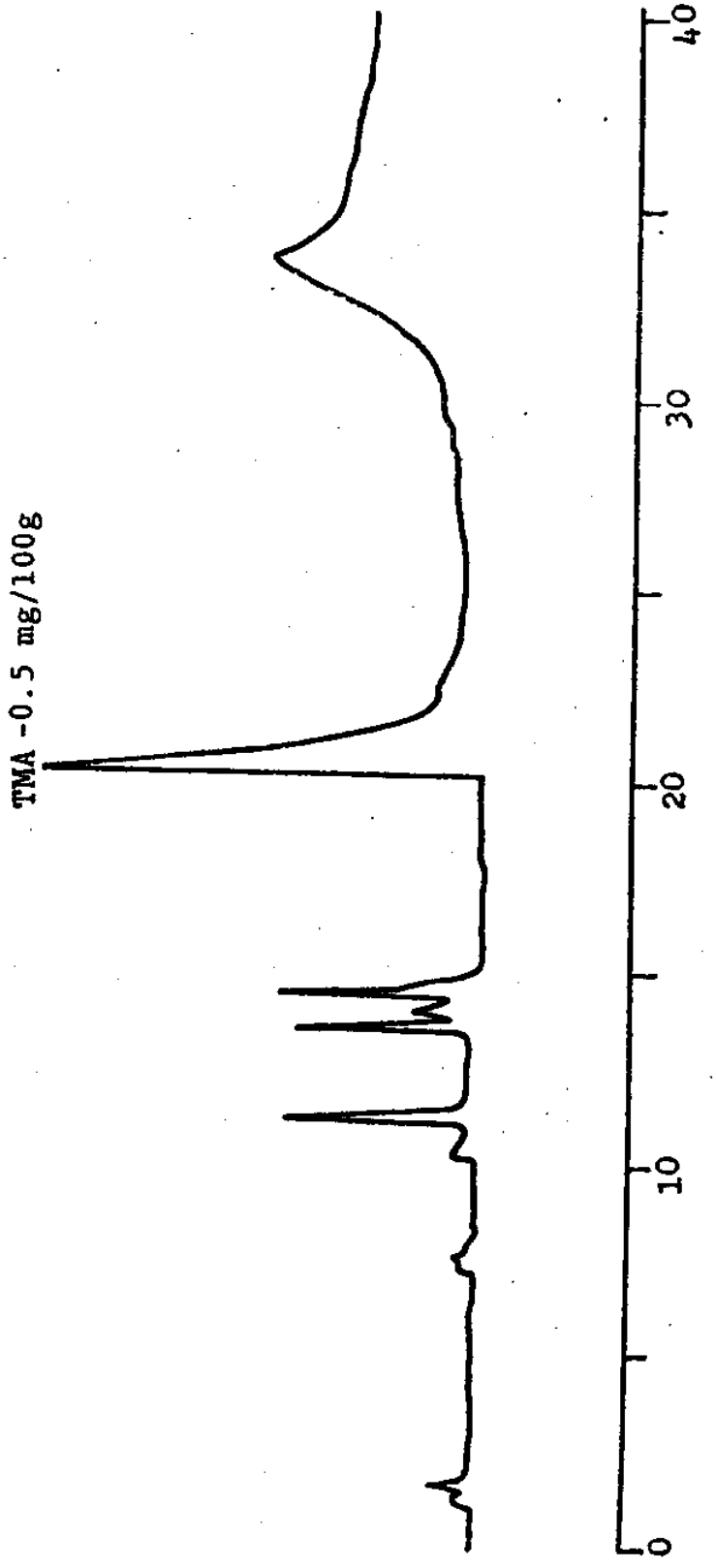

FIGURE 6. Gas chromatogram of fresh green headless processed shrimp - breaded.

Sodium tripolyphosphage has been used quite extensively in shrimp processing and a fresh green headless unpeeled shrimp sample previously treated with sodium tripolyphosphate was also analyzed and the gas chromatogram is seen in Figure 7. As the sample was taken at the same area of the processing line as a fresh green headless unpeeled shrimp, it is not surprising that both were identical for TMA values.

To correlate chemical changes noted with morphological changes, scanning electron microscopy was utilized. Figure 8 is the control sample showing a fresh green headless peeled shrimp at 4000x magnification. The photomicrograph revealed a completely normal protein structure with the muscle fibers essentially intact. Figure 9 is the photomicrograph of a green headless peeled shrimp sample at the stage of earliest detectable sensory spoilage. Here, it is noted that the outer membrane of the muscle fiber is completely missing and the fibers themselves are beginning to deteriorate and decompose. Figure 10 is a photomicrograph of a green headless peeled shrimp sample at the stage of complete sensory spoilage. It is quite obvious that there is a complete and total degradation of the muscle fiber. The sample is also completely dehydrated and the protein of the muscle fiber has almost completely disappeared. Electron micrographs of samples prior to the onset of spoilage showed little morphological changes or differences from the original fresh shrimp samples.

Thus, it is quite evident that the obvious morphological changes occurring from the onset of spoilage as noted by the scanning electron photomicrographs correlated quite qell with the chemical changes measured by gas chromatographic techniques.

Thus, it appears that this gas chromatographic technique is simple, rapid and effective for measurement of TMA values as an indication of the onset of spoilage in shrimp samples. The time involved from the preparation of the sample to the completion of the analysis was less than 1 hr with no extractions or derivatizations required before using the gas chromatograph, as the sample is placed directly into the instrument.

SUMMARY

A direct gas chromatographic technique was used to measure volatiles, especially trimethylamine, as an index of shrimp quality. The gas chromatographic technique proved to be a rapid, sensitive and practical means of measuring trimethylamine and other volatiles as a measurement of shrimp spoilage and decomposition. Morphological changes as seen in scanning electron photomicrographs correlated closely with chemical changes detected by the gas chromatograph. Further research is anticipated and will be carried out on the other detectable volatiles as they also may prove effective quality indicators.

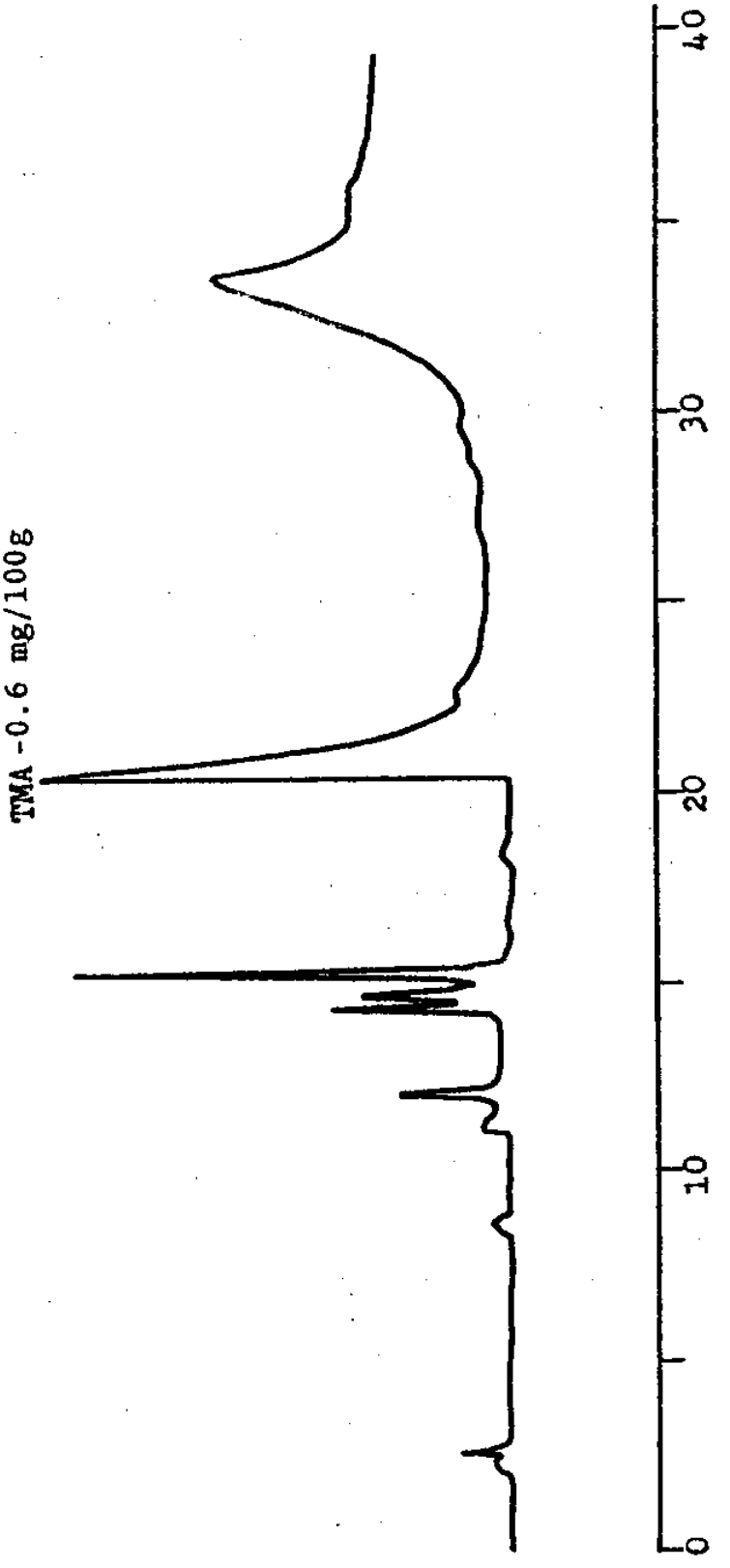

FIGURE 7. Gas chromatogram of fresh green headless processed shrimp - $Na_5P_3O_{10}$.

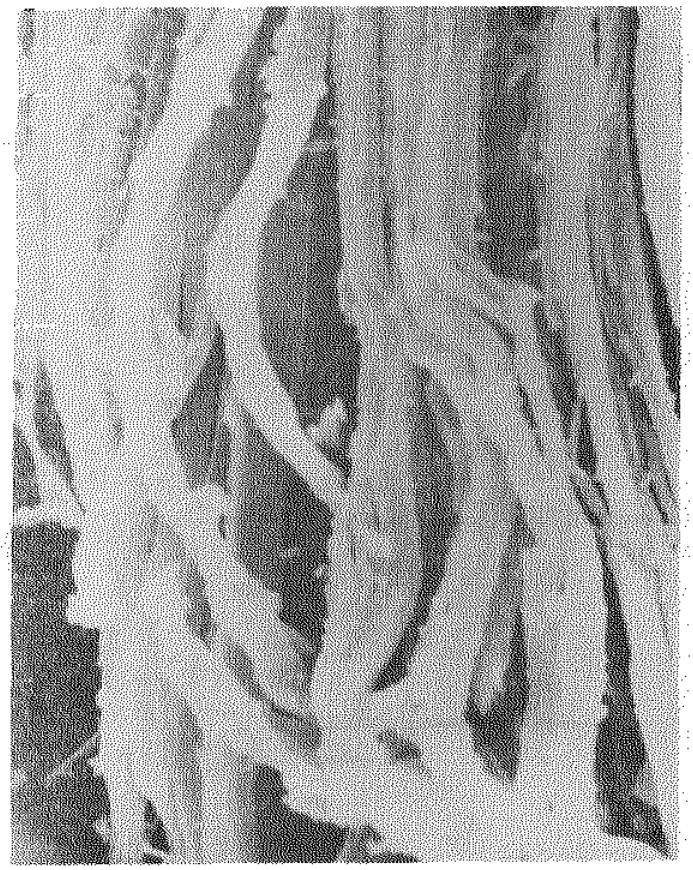

FIGURE 8. Scanning Electron Micrograph of a Fresh Green Headless Shrimp (4000x).

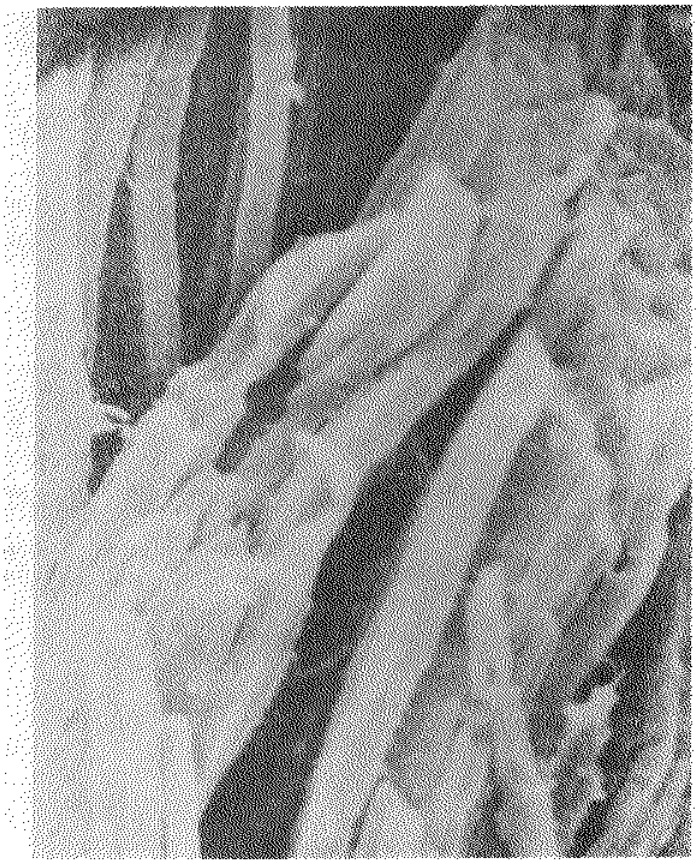

FIGURE 9. Scanning Electron Micrograph of a Green Headless Shrimp at the Stage of Earliest Organoleptic Detection of Spoilage (4000x).

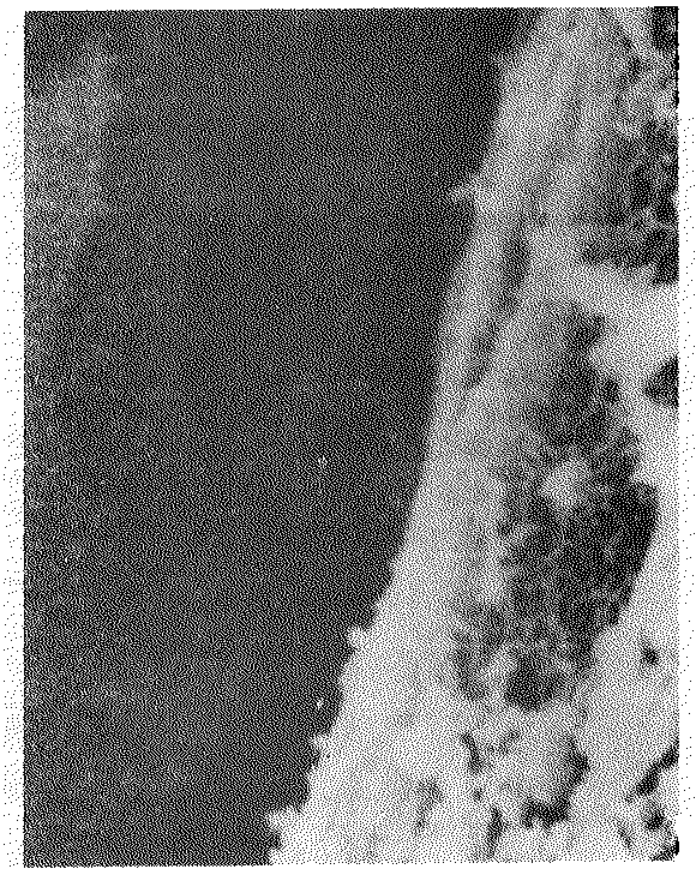

FIGURE 10. Scanning Electron Micrograph of a Green Headless Shrimp at Stage of Complete Decomposition (4000x).

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INDOLE FORMATION IN SHRIMP

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INTRODUCTION

Due to recent actions by the Food and Drug Administration (FDA), the use of indole as a quality indicator for fresh and frozen shrimp has attracted much attention. Among numerous methods proposed as indicators of decomposition in shrimp, indole was suggested as early as 1946 by Duggan and Strasburger (3). In their work they reported on a good correlation between indole levels and organoleptic evaluations.

Although indole is believed to be present in shrimp as a result of bacterial activity prior to freezing (6), the biochemical mechanisms of indole formation during storage of shrimp have never been investigated. Not only is there a need to determine which type of indole producing microorganisms that are present on shrimp, but also whether indole can be formed by shrimp tissue enzymes.

Indole has traditionally been determined in shrimp by a colorimetric method which involves a time-consuming steam distillation with a cumbersome extraction of the distillate (1). More recent methods include gas-liquid chromatography (2), fluorometric analysis (4), as well as liquid chromatography (7). Most of these methods require well-trained personnel and sophisticated and expensive instrumentation. Consequently, these methods are not practical for the seafood industry as a daily quality control measure.

The objectives of this study were to: (a) develop a modified method for measuring indole in shrimp, (b) differentiate whether indole is produced by bacterial enzyme or tissue enzyme, and (c) determine the stability of indole production in shrimp during storage at different temperatures.

METHODS AND MATERIALS

Modified Spectrophotometric Method for Measuring Indole in Shrimp

Brown shrimp (Penaeus aztecus), obtained directly from shrimp trawlers in Aransas Pass, Texas, were immediately packed in ice and shipped to the laboratory in College Station. In order to induce different levels of decomposition, the shrimp were stored at three temperatures for varying time intervals, as shown in Table 1.

Forty grams of shrimp were homogenized with 80 ml of a 7% trichloroacetic acid (TCA) solution in a Waring blender for 1 min. To this was added 80 ml of ice-cold petroleum ether and the mixture blended again for 1 min. The homogenate was transferred to 250 ml centrifuge bottles and centrifuged for 10 min at 10,000 rpm. The supernatant was filtered through a Watman No. 1 filter paper under slight suction and the filtrate transferred to a 250 ml separatory funnel. After the two layers had separated, the acid layer was again transferred to a second 250 ml separatory funnel.

Table 1. Comparison of AOAC colorimetric and modified colorimetric methods for determining indole in shrimp decomposed under different conditions[a] (µg indole/100 g shrimp, hydrated basis).

Sample	Temperature	Time	AOAC Colorimetric	Modified Colorimetric
1	22°C	13 hr	5.85	5.82
2	22°C	16 hr	53.79	62.50
3	22°C	18 hr	120.45	103.90
4	ice	6 days	1.17	1.25
5	ice	9 days	4.21	5.00
6	ice	10 days	7.02	6.25
7	ice	11 days	9.12	10.00
8	ice	13 days	17.54	15.00
9	11°C	24 hr	4.68	9.85
10	11°C	60 hr	18.71	23.16

[a]Correlation coefficient = 0.98

The TCA-denatured protein precipitate separated by centrifugation was washed with 40 ml light petroleum and filtered as described above. The filtrate was added back to the second 250 ml separatory funnel already containing the TCA layer from the first extraction. After vigorous shaking for 1 min the two layers were allowed to separate. The lower acid layer was transferred to a third separatory funnel and extracted for the third time with 40 ml light petroleum.

All the light petroleum extracts were combined into one separatory funnel and indole extracted with exactly 5 ml of freshly prepared Ehrlich's reagent for 1 min under vigorous shaking. The rose indole complex formed is insoluble in light petroleum, and indole is thus quantitatively transferred to the Ehrlich's reagent layer. When the layers had separated and cleared, part of the lower colored complex was transferred to a 1 cm path and read at 570 nm against reagent blank. The indole concentration in the extracts was determined from a standard curve (Figure 1).

PREPARATION OF STANDARD CURVES

Pure indole. Between 0.5 and 4 ml (5 µg to 40 µg) stock indole solution was accurately measured into 80 ml of TCA in a separatory funnel. The indole was re-extracted by procedures described above and a standard curve constructed.

Shrimp spiked with indole. To 40 g peeled and deveined shrimp free of indole was added from 0.5 ml to 4 ml stock indole solution. After mixing, all the light petroleum was allowed to evaporate. The indole was extracted from the samples by the procedures described above and a standard curve constructed.

Differentiation of Bacterial Enzyme and Tissue Enzyme

Brown shrimp (Penaeus aztecus), obtained from shrimp trawlers in Aransas Pass, Texas, were immediately packed in ice and shipped to the laboratory. Shrimp were homogenized with sterile distilled water in a ratio of 1:2 and divided into two equal portions. One portion was treated

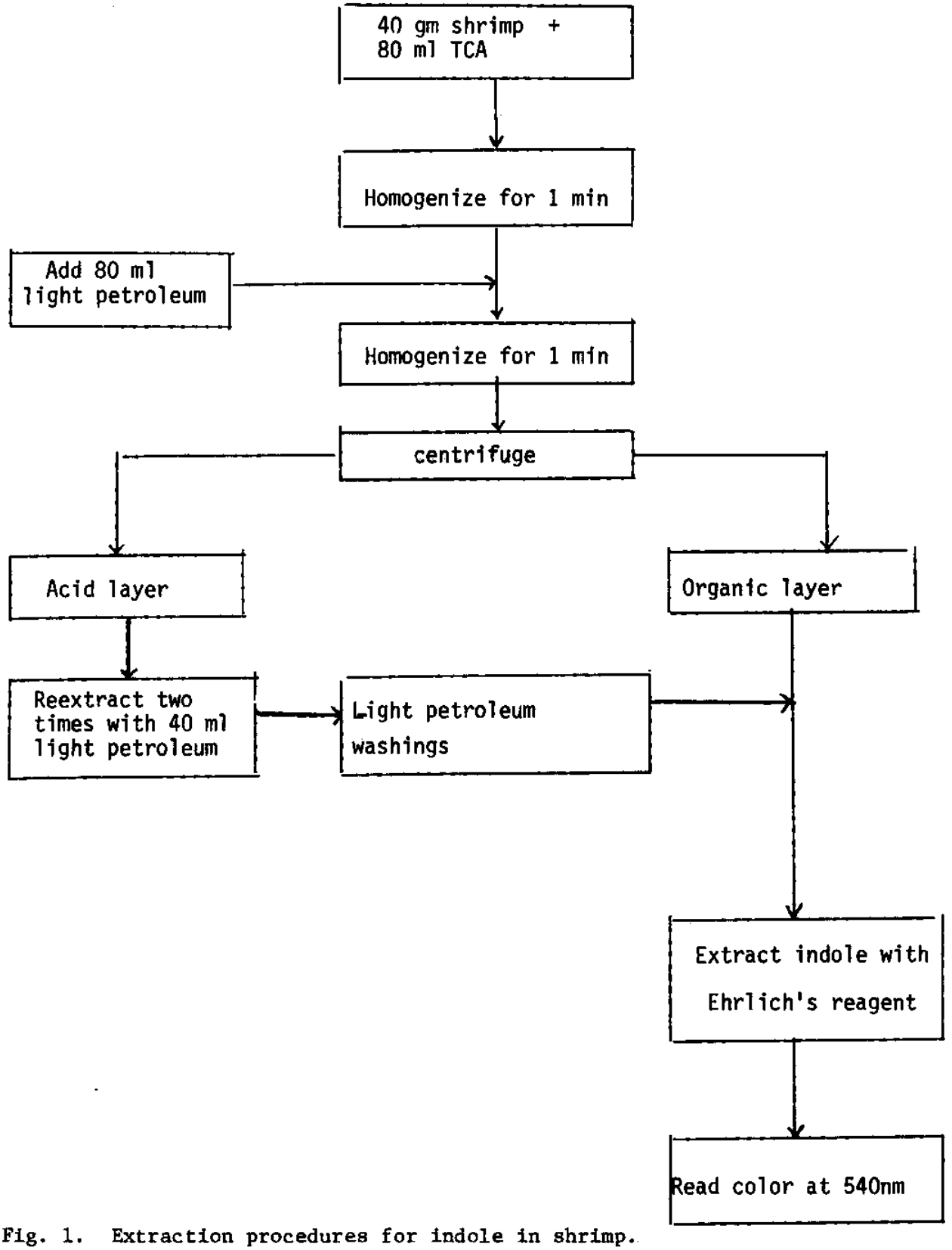

Fig. 1. Extraction procedures for indole in shrimp.

with antibiotics (dihydrostreptomycin and chloramphenicol), and the other portion was kept as a control. Each portion was further divided into five separate sub-portions and stored at five different temperatures (4°, 8°, 12°, 16° and 22°C.).

The Development of Indole in Shrimp During Storage at Different Temperatures

To observe the development of indole during storage, shrimp were divided into four groups with were held at four different temperatures (on ice, 4°, 11° and 22°C). Traditional quality indicators such as Total Plate Count (TPC), Trimethylamine (TMA), and Total Volatile Nitrogen (TVN) were also determined during the storage period.

RESULTS AND DISCUSSION

Modified Spectrophotometric Method

The basic spectrophotometric principles are the same for both the modified method and the official steam distillation method. However, the modified method is more convenient, time saving, and it only requires simple instrumentation. Figure 2 shows the relationship between pure indole extracted from TCA and indole extracted from spiked shrimp. As indicated, indole extracted from spiked shrimp was recovered at a level of 90%. In order to incorporate the recovery factor into the extraction procedure, the standard curve used throughout this study was constructed from spiked shrimp free of indole.

Shrimp of various degrees of decomposition (Table 1) were divided into two portions, one of which was analyzed for indole according to the procedure described above, while the other was analyzed for indole according to the official AOAC method. A correlation coefficient of 0.98 indicates a good agreement between the two methods. In order to compare the properties of the colored complex formed from pure indole to the complex extracted from decomposing shrimp, the two complexes were scanned in the visible region. As is evident from Figure 3, the two complexes had similar visible absorption spectra, indicating that the extracted compound from spoiled shrimp was indole or some indole-related substance.

Differentiation of Bacterial Enzyme and Tissue Enzyme

When shrimp extracts, with and without antibiotics, were kept at five different temperatures, no indole was formed in the antibiotic treated samples, while shrimp extract without antibiotics showed high indole production. It is thus evident that production of indole in shrimp is strictly due to microbial activity. Of 1,600 picked colonies, 42 isolates have been shown to be indole producers. No indole producing bacteria could be isolated on shrimp stored at or below 4°C.

The Development of Indole During Storage

Figures 4-7 show the relationships between indole production and other quality indicators. The initial values of TVN and TPC were within acceptable limits, while TMA and indole could not be detected at zero day. With the exception of TVN values for shrimp stored on ice, all increased during the storage period. The loss of TVN in shrimp during storage on ice is due to the washing action of the melting ice. The quality of shrimp is best reflected by TPC and TVN values. According to Stansby (5), the TVN value per 100 g sample as quality index for borderline edibility is 20-25. The FDA currently considers a level of 20-25 µg indole/100 g shrimp as

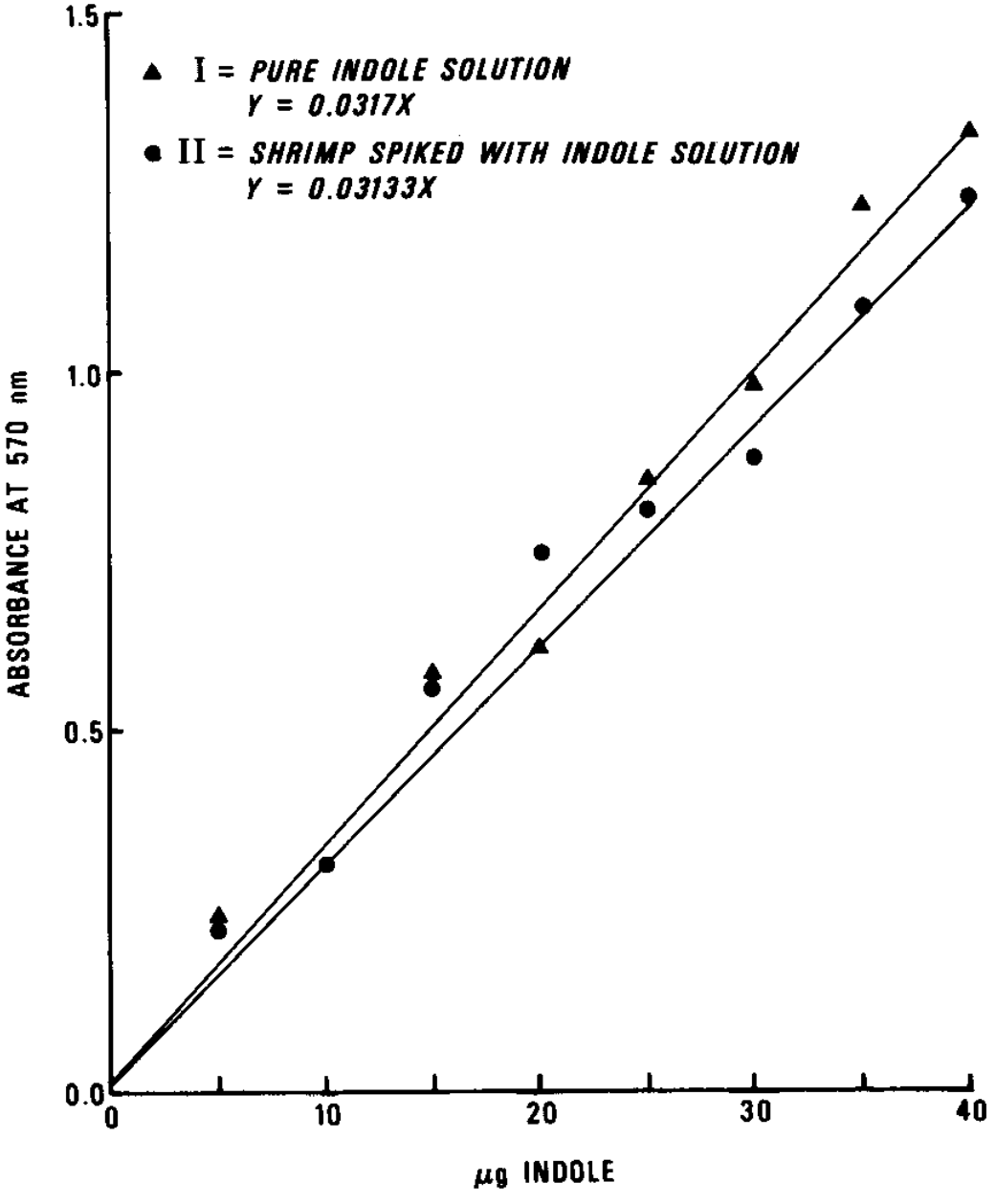

Fig. 2. Standard curves for pure indole solution (I) and for shrimp spiked with indole (II).

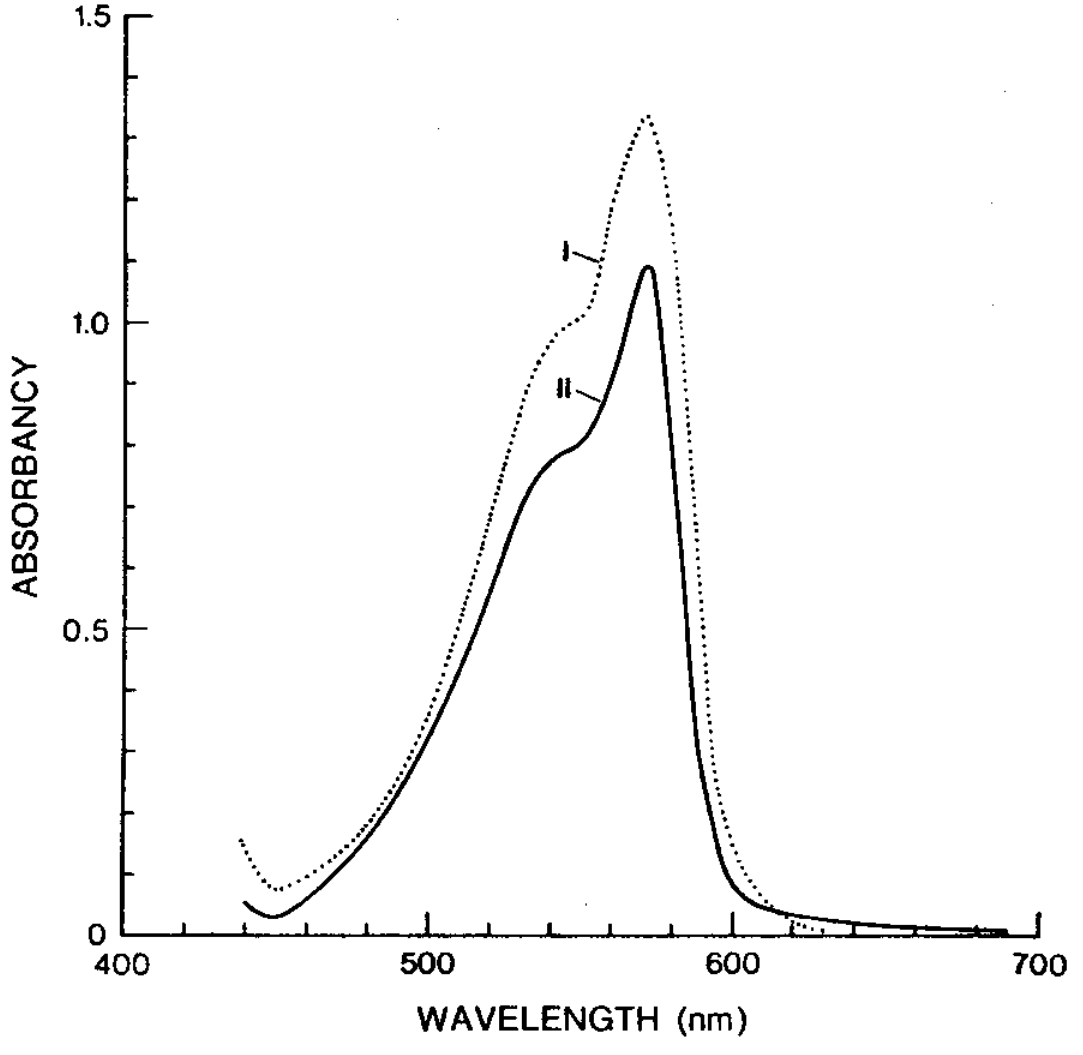

Fig. 3. Visible spectra of pure indole derivative and indole derivative extracted from decomposed shrimp.
I. Spectrum from decomposed shrimp.
II. Spectrum from pure indole.

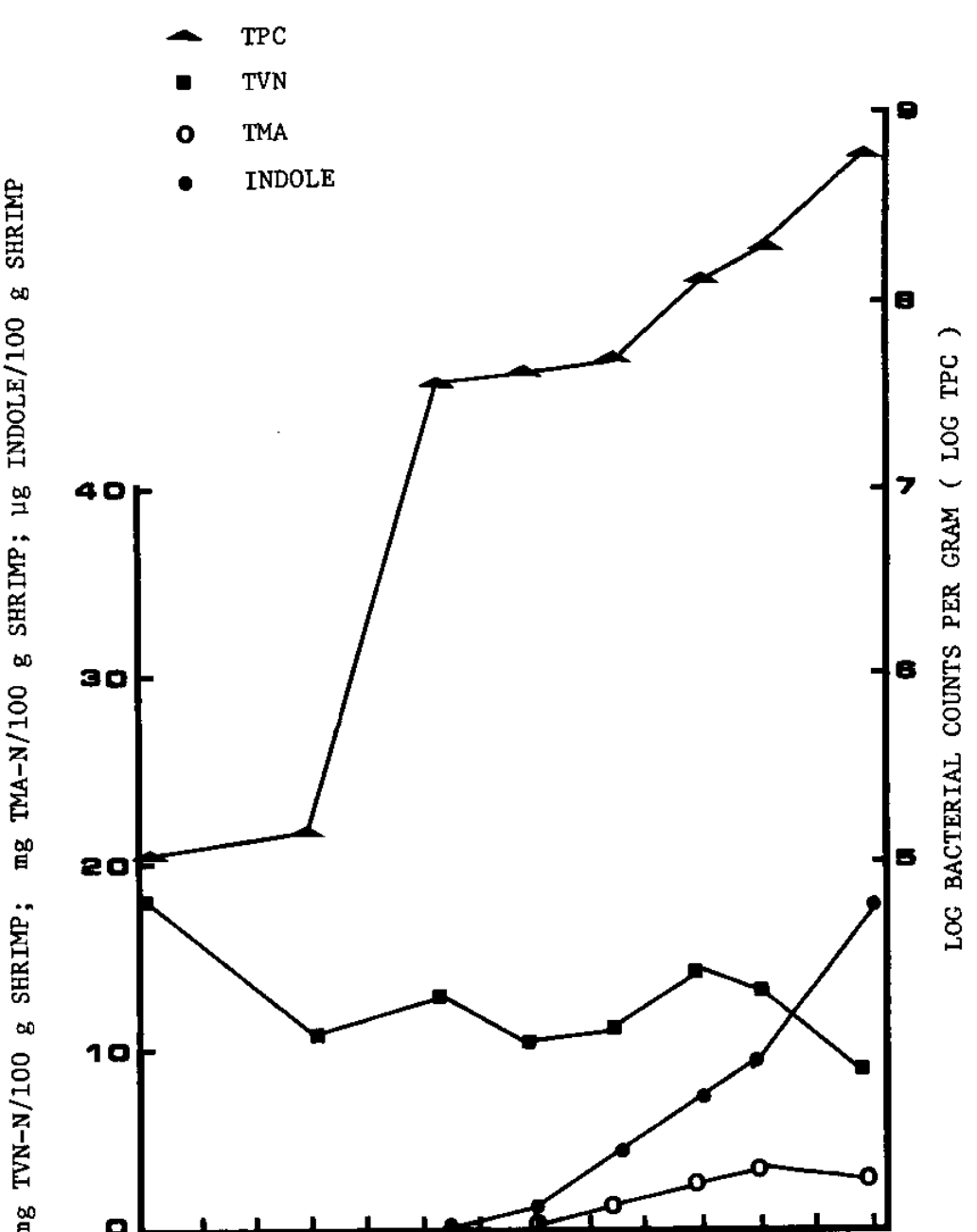

Fig. 4. Microbiological and chemical analysis of shrimp held on ice.

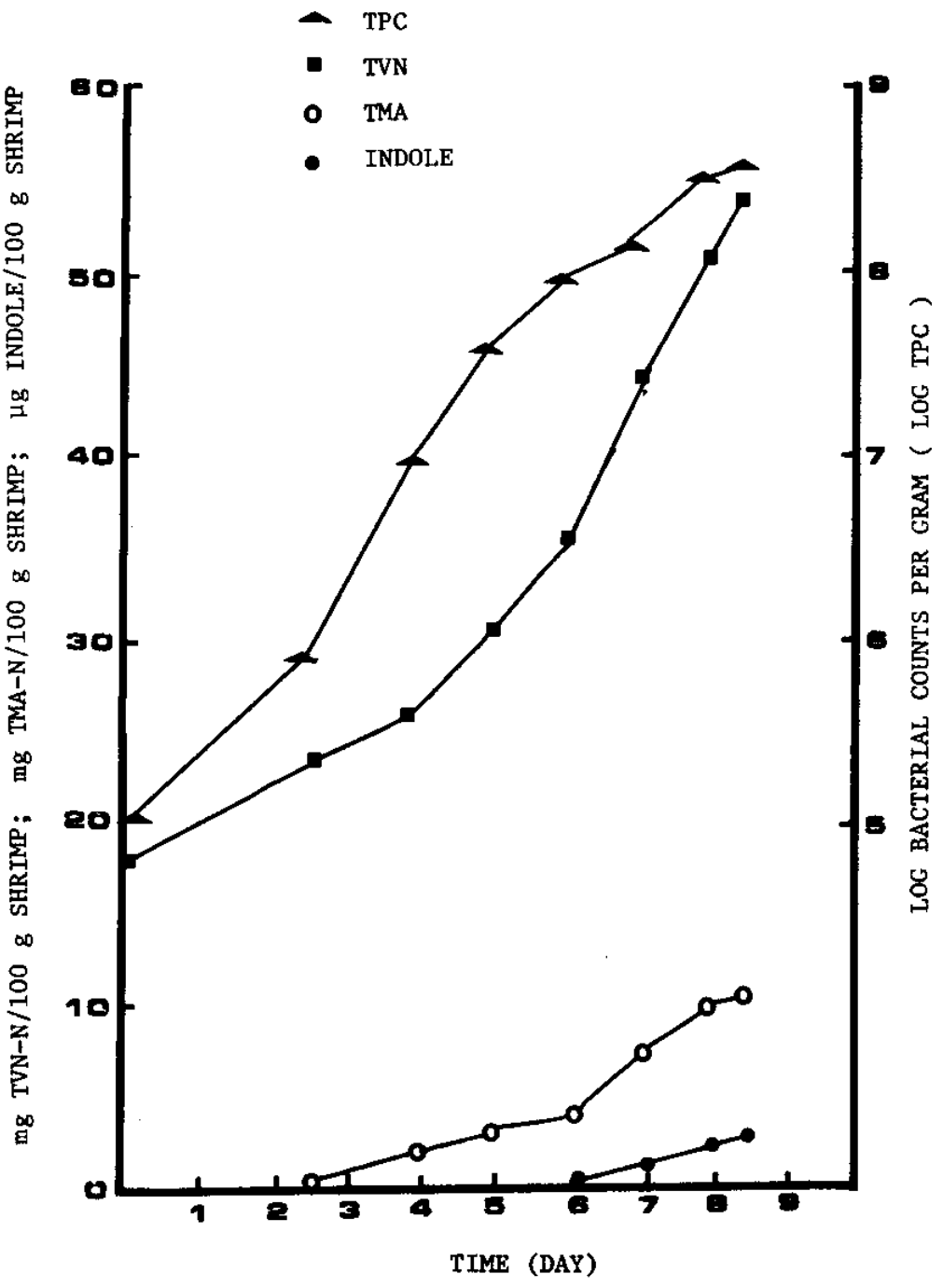

Fig. 5. Microbiological and chemical analysis of shrimp held at 4°C

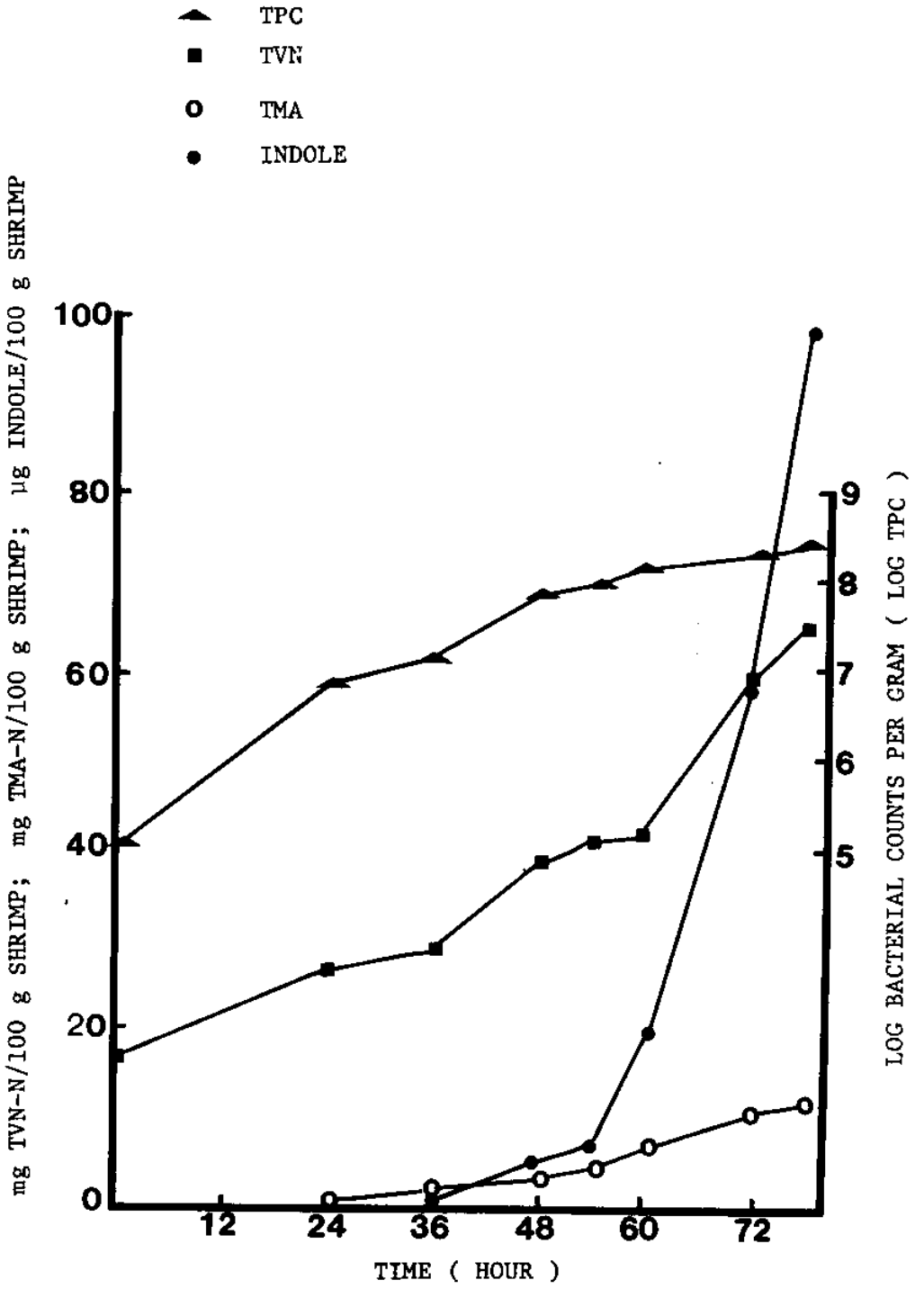

Fig. 6. Microbiological and chemical analysis of shrimp held at 11°C

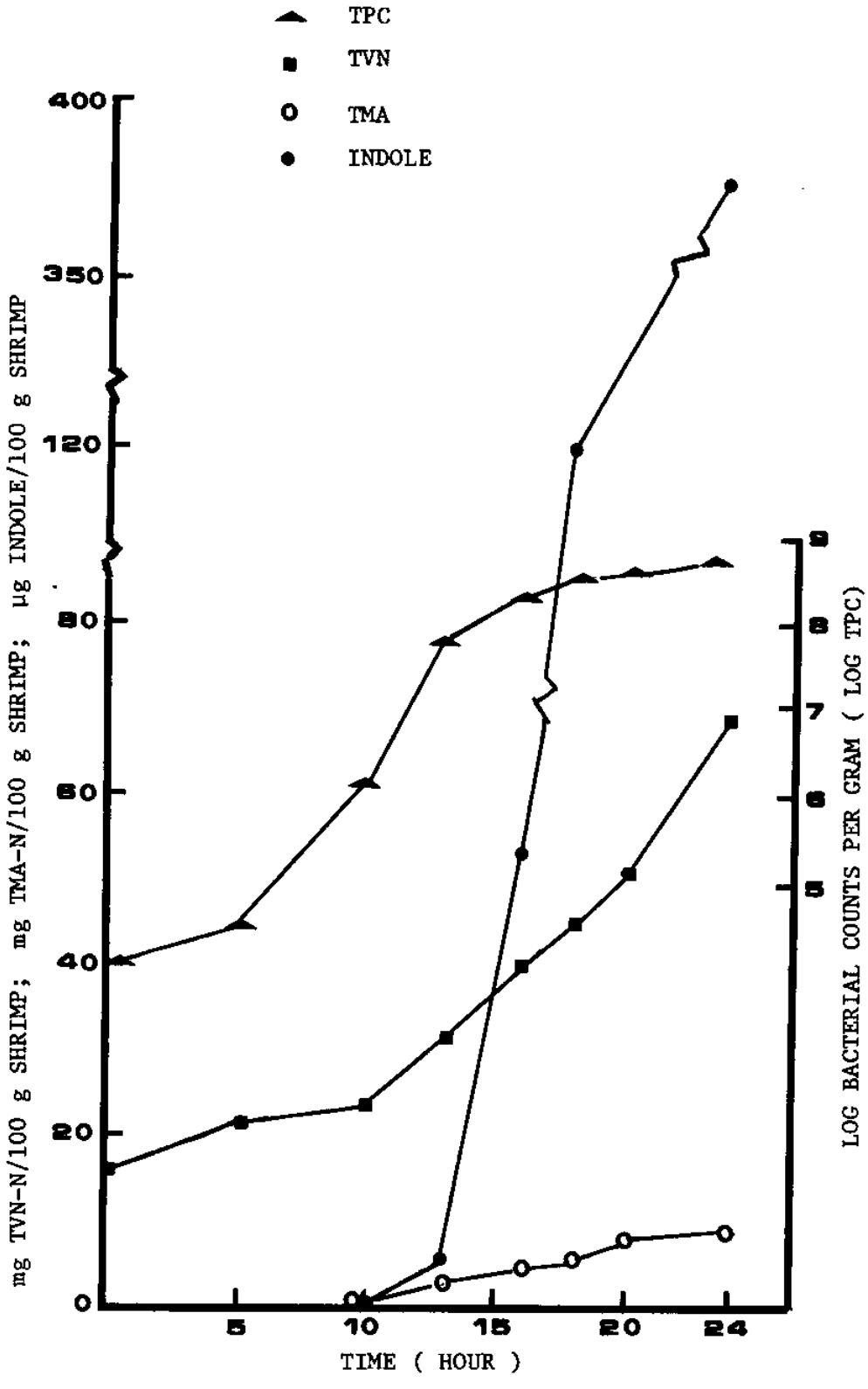

Fig. 7. Microbiological and chemical analysis of shrimp held at 22°C

unacceptable. Figure 4 shows that when TPC reaced 10^7/g with a TVN value of 24 mg/100 g shrimp, indole had not yet accumulated. Concurrently, when indole appeared on the sixth day of ice storage, TPC and TVN values had already indicated that the shrimp was definitely spoiled. Figures 6 and 7 show that indole increased tremendously in shrimp during storage at elevated temperatures as when compared to shrimp held at low temperatures.

CONCLUSIONS

Indole can be extracted from decomposing shrimp by using light petroleum on TCA-precipitated shrimp muscle. The method is simple, rapid and time-saving.

By using antibiotic-treated samples, indole was shown to be strictly a bacterial metabolite and no indole was formed by tissue enzymes.

Finally, indole has been shown to be a good indicator of temperature abuse of shrimp. It is, however, not a suitable uniform quality indicator.

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DIFFERENTIATION OF FROZEN-THAWED AND FRESH SHRIMP

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Shrimp which have been frozen and held for varying periods of time are frequently thawed and sold to the consumer as fresh shrimp. It has been shown that frozen-thawed shrimp have a greater ratio of fluid tissue substances to solid substances than do fresh shrimp. More importantly, frozen-thawed shrimp exhibit a much shorter shelf life than do fresh shrimp. Thus, the marketing of frozen-thawed shrimp as fresh represents a form of consumer fraud.

At present, no method has been developed to differentiate fresh from frozen-thawed shrimp. However, work in this general area has been conducted on other species of seafood. Gould and Medler (1970) and Gould (1973) demonstrated the effectiveness of malate dehydrogenase (MDH) isoenzymes in differentiating frozen-thawed from fresh oysters. Rehbein, et al. (1978) utilized the specific activity ratios of two lysosomal enzymes (α-glucosidase and β-N-acetylglucosaminidase) in differentiating fresh from frozen-thawed finfish (cod, redfish, saithe, and haddock). In their study, the activity ratio increased six to nine times for α-glucosidase and three to five times for β-N-acetylglucosaminidase in frozen-thawed fillets.

Techniques applied to one species are not always appropriate for another. For example, the release of the mitochondrial isoenzyme of glutamate-oxaloacetate-transaminase, which is frequently used to detect freeze-thawing for various meat products, could not be used with carp, since the mitochondria were destroyed to a high degree with concomitant release of the izoenzyme during normal ice storage of carp fillets (Hamm and Masic, 1971). Thus, it is necessary to develop and adapt specific techniques for each seafood product in order to differentiate fresh from frozen-thawed samples.

Another approach to the detection of thawed shrimp is visual observation for mechanical and/or chemical damage in thawed tissue utilizing light microscopic techniques. Freezing often crystallizes cellular fluids producing "holes" that can be readily seen in sectioned and stained tissue preparations. Since freezing results in subcellular rupture, staining for enzymes specific for particular subcellular organelles (i.e., acid phosphatase in lysosomes) should result in a different staining pattern in frozen-thawed shrimp than in fresh shrimp. Thus, in tissues where the lysosomes have been disrupted--in this case due to freezing--the stain should no longer be localized within the lysosome but found throughout the cell.

MATERIALS AND METHODS

Histochemistry

For histochemical studies, the shrimp were frozen and sectioned (4-6 μm) in a cryostat (Damon/IEC), and stained with general (Hemotoxylin

and Eosin) or enzyme specific stains. Attempts to establish acid phosphatase sites employed two methods: that of Gomorís (Humanson, 1972) as well as the azo-coupling technique described by Lynch (1976).

Shrimp Preparation

Shrimp samples were obtained from reliable coastal dealers and stored on ice in alternating layers. Nine-day-old shrimp were divided into two groups. The first was frozen at -10°C, while the second was subdivided, and the extracts and press juices obtained from these two halves. After 48 hours, the first group was thawed and subdivided, and press juices and extracts were prepared the same as the fresh samples. Press juices were prepared by adding peeled, deheaded and deveined shrimp to 0.25M sucrose 1:1 (w/v) and centrifuged at 28,000 XG for 30 min. Sorvall RC-5). The liquid which was carefully removed from the pellet represented the press juice. Extracts were prepared by homogenizing peeled, deheaded and deveined shrimp 1:3 (w/v) with distilled water and centrifuging at 28,000 XG for 30 min. The liquid which was carefully removed from the pellet represented the extract. The press juices, extracts and drippings from the fresh and frozen-thawed samples were pipeted into 1 ml vials and frozen. Vials were thawed out as needed.

Enzyme Protocols

Assays were followed employing either a Turner, model 350, spectrophotometer or a Bausch and Lomb Spectronic 2000 spectrophotometer equipped with a thermoelectric flow cell. Press juices were filtered through a 0.45 µm millipore filter prior to analysis in order to minimize precipitation of proteins when the acid buffer was added.

Acid phosphatase was determined by a modification of the method described by Bergmeyer (1974). The assay contained 1 ml of 0.05M Barbituric acid pH 4.8, 0.03 ml 0.6M p-nitrophenylphosphate, and 0.2 ml press juice or tissue extract. The reaction was allowed to proceed at room temperature (24°C) for 30 min., stopped by the addition of 2.0 ml of 0.5M NaOH and read against a blank consisting of all reagents except enzyme at 405 nm.

Glutamate dehydrogenase was determined by the method of Schmidt (1974). The assay contained 1.4 ml Triethanolamine buffer (70mM, pH 8.0; 3.6mM EDTA) 0.04 ml NADP/ADP solution (10.25mM β-NADH; 50mM ADP), 0.06 ml 3.3M ammonium acetate, 0.08 ml lactate dehydrogenase (100 U/ml) and 0.02 ml press juice. After incubating for 5 min. at room temperature, 0.05 ml of 0.233M α-ketoglutarate was added and the solution drawn into and the reaction followed on the Spectronic 2000 for 15 min. at 340 nm.

Malate dehydrogenase was determined using the method of Bergmeyer (1974). The assay contained 3.0 ml 0.1M K-phosphate buffer pH 7.5, 0.15 ml oxaloacetate (2 mg/ml buffer), and 0.05 ml NADH (10 mg/ml). After a preincubation of 2 min., 0.01 ml press juice was added. The reaction was followed for 15 min. at 340 nm.

Disc Electrophoresis of Press Juices for Malate Dehydrogenase

Chemical formulations for gels were prepared according to Canalco Bulletin (1968) for standard 7% gels. Glass tubing measuring 5 mm (i.d.) by 10 cm were used for columns. The bottoms of the columns were sealed with Parafilm and gel solutions were deaerated under vacuum before casting. Separating gel was applied to a height of 7.5 cm and overlaid with 0.5 cm

H_2O to achieve a flat gel surface. Polymerization proceeded overnight. After removal of H_2O, 0.2 ml stacking gel was added and overlaid with H_2O as before. A fluorescent light was placed 30 cm from the tubes for 20 min. and then moved to about 15 cm for a total polymerization time of 3 hrs.

Press juices were filtered through a 0.45 µm filter and made more dense by the addition of sucrose equivalent to about one-third the sample volume. Bromophenol blue (0.2%) was added as a tracking dye, and the same buffer used in the upper and lower chambers (2.48 mM Tris, 19.17 mM Glycine; pH 9.5). Following application of 80 µl press juice (roughly 480 µg protein/gel) 3.4 mA were applied per gel for 1 hr. The gels were stained for 10-20 min. in the dark according to the method of Weber (1974). The dye system consisted of two solutions: the coenzyme/cofactor-dye contained 30 mg NAD, 5 mg Phenazine Methosulfate, 45 mg Nitro Blue Tetrazolium, and 30 mg $MgCl_2$, dissolved in 100 ml of 0.01 M phosphate buffer, pH 7.5. The substrate buffer consisted of 2% malate in 0.01 M phosphate buffer, pH 7.5. Immediately prior to use, the cofactor dye was mixed with substrate buffer 6:1. The gels were preserved in a 5% acetic acid, 5% methanol fixative.

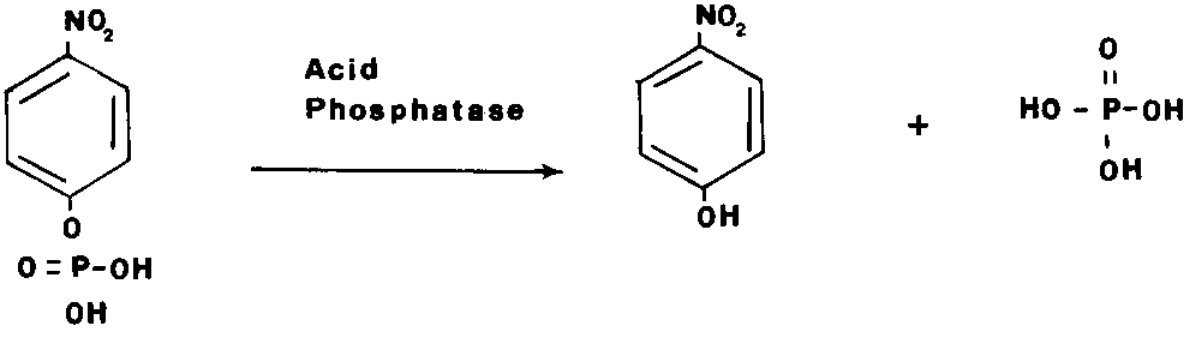
RESULTS AND DISCUSSION

When cytochemically staining for acid phosphatase, it is necessary to use frozen sections in order to maintain the highest enzyme activity. In this project, however, this presented a problem in that it would be necessary to freeze the tissue before sectioning, even though the objective of the project was to determine if the tissue had been previously frozen. Thus, it was the conclusion of this portion of the study that new, non-traditional staining techniques would need to be developed in order to utilize microscopic techniques to differentiate fresh from frozen-thawed shrimp tissue. Since extensive cellular damage from the freezing was evident, it was apparent that techniques utilizing enzymatic assays would be more productive.

If an organelle is ruptured during freezing, one would expect the enzymes normally localized within that organelle to be released and hence the specific activity for that enzyme to increase in the press juice. On the other hand, those enzymes which are inactivated (denatured) by freezing, would exhibit a lower enzymatic activity in the press juice.

Previous work by Rehbein, et al. (1978) demonstrated an increase of six to nine times in specific activity for α-glucosidase and three to five times for β-N-acetylglucosaminidase in frozen-thawed fish fillets compared to fresh fillets. Rehbein employed a citrate buffer to maintain the acid pH necessary to assay for these lysosomal enzymes. However, citrate is a common metabolite, and preparations of crude press juices would be expected to contain enzymes capable of reacting with the citrate. Findings from this project confirm that these enzymes are indeed present, and that the enzyme/buffer reaction gives a significant change in absorbance, probably accounting for much of the large activity found by Rehbein in frozen-thawed shrimp. Therefore, it would appear that these investigators were measuring enzymes reacting with the buffer in addition to the enzymes they believed they were assaying. We found citrate, benzoate, phthalate and barbital buffers to all to be reactive with press

juices. Phosphate buffer was also unacceptable because it inhibits acid phosphatase. On the other hand, barbiturate buffer has been found suitable for these assays, and is thus the buffer of choice



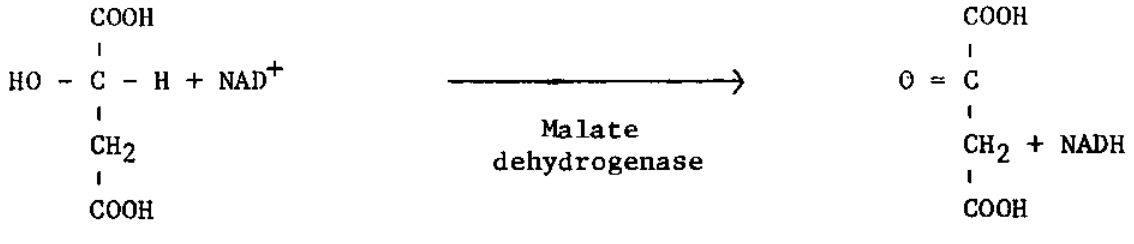
ρ-Nitrophenyl Phosphate (colorless) **ρ-Nitrophenol (Yellow)** **Phosphate**

As shown in Table 1, the specific activity for acid phosphatase was consistently higher in shrimp which had been frozen-thawed than in fresh shrimp. This finding was consistent with the earlier, microscopic observations which suggested that freezing resulted in lysosomal rupture. Of even more importance, however, is the finding that a simple rapid assay for acid phosphatase appears suitable for differentiating fresh from frozen-thawed shrimp.

TABLE 1. SPECIFIC ACTIVITIES OF SELECTED ENZYMES IN PRESS JUICES

Enzyme	Fresh	Frozen-Thawed	Ratio (Frozen-Thawed/Fresh)
Malate DH	131.10	71.80	0.6
Glutamate DH	14.50	13.90	1.0
Acid Phosphorous	1.63	1.96	1.2

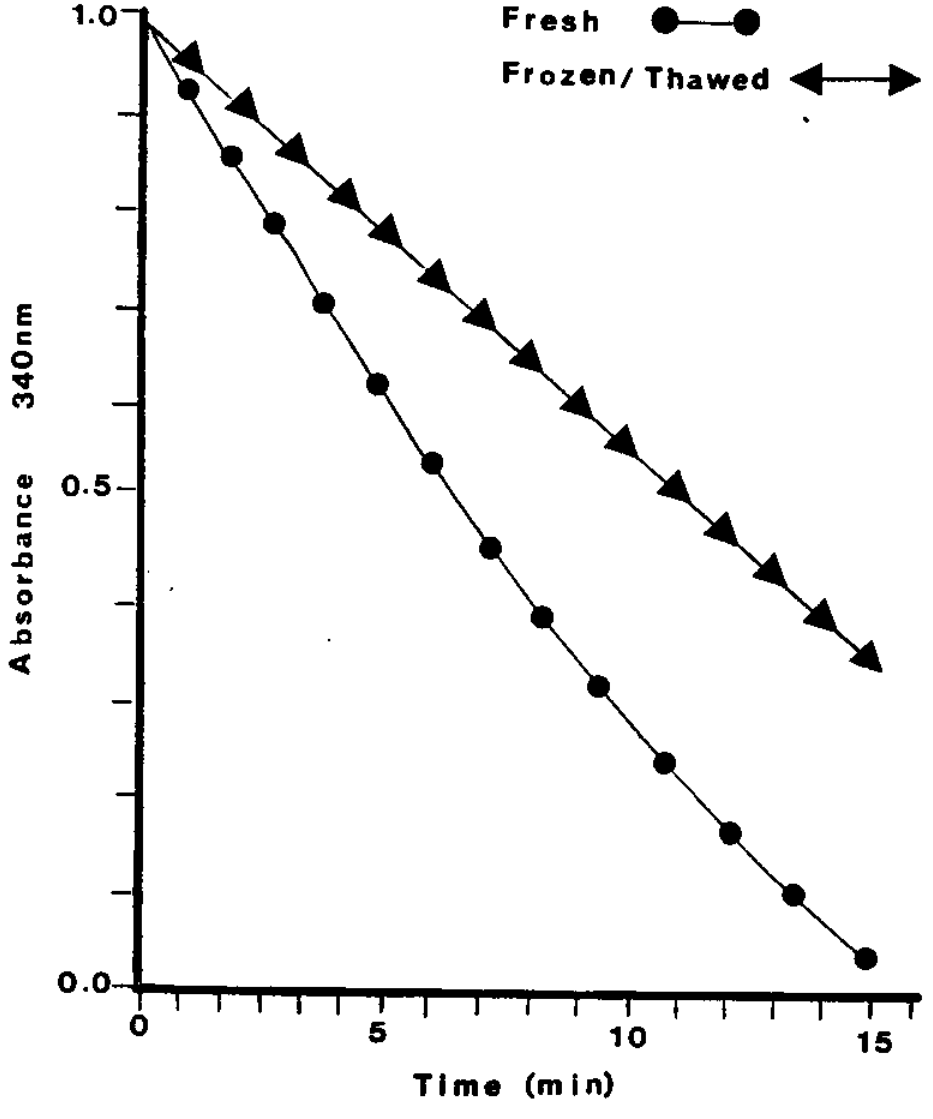
Sp. Act. = Abs min^{-1} x 10^{-2}/mg protein



Assays for MDH (Table 1; Fig. 1) revealed a 55% decrease of specific activity in frozen-thawed press juice below that found in fresh. It would seem then, that the enzyme is partially denatured and/or inactivated by freezing. Thus,

Figure 1

Enzymatic Activity for Malate Dehydrogenase



the measurement of MDH activity would also be appropriate for differentiating fresh from frozen-thawed shrimp.

Disc electrophoresis followed by staining for MDH resulted in eight major bands from fresh press juices, while frozen-thawed press juices gave five or six bands depending on the length of time allowed for staining (see Fig. 2). All bands were of varying intensities of violet, except for band D which stained pink. However, it was shown that both this band, as well as band A, were due to a nonspecific reaction with the stain solution itself and were thus not isoenzyme forms of MDH.

Band C was absent in frozen-thawed gels stained 10 min. or less, while bands A and B were absent in all frozen-thawed gels stained as long as 30 min. As is evident by densitometer scans, all peaks on the fresh gels are larger than the frozen-thawed peaks with the exception of H, which is more intense on the frozen-thawed gels (see Fig. 3). Bands C and D appear as one peak on the graphs.

The loss of specific isoenzymes of MDH on freezing is consistent with the earlier finding of decreased MDH activity on freezing. Though more involved than enzyme assays, disc electrophoretic separation of MDH isoenzymes offers a relatively easy method to distinguish fresh from frozen-thawed shrimp samples.

CONCLUSIONS

Three methods were developed for the differentiation of frozen-thawed from fresh shrimp. Two methods rely on the measurement of enzymatic activity (acid phosphatase and malate dehydrogenase), while the third method utilizes the electrophoretic separation of malate dehydrogenase isoenzymes. Although the two enzymatic methods are both faster and simpler, it is easier to differentiate fresh from frozen-thawed shrimp using the electrophoretic techniques.

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Figure 2

Isoenzymes of Malate Dehydrogenase

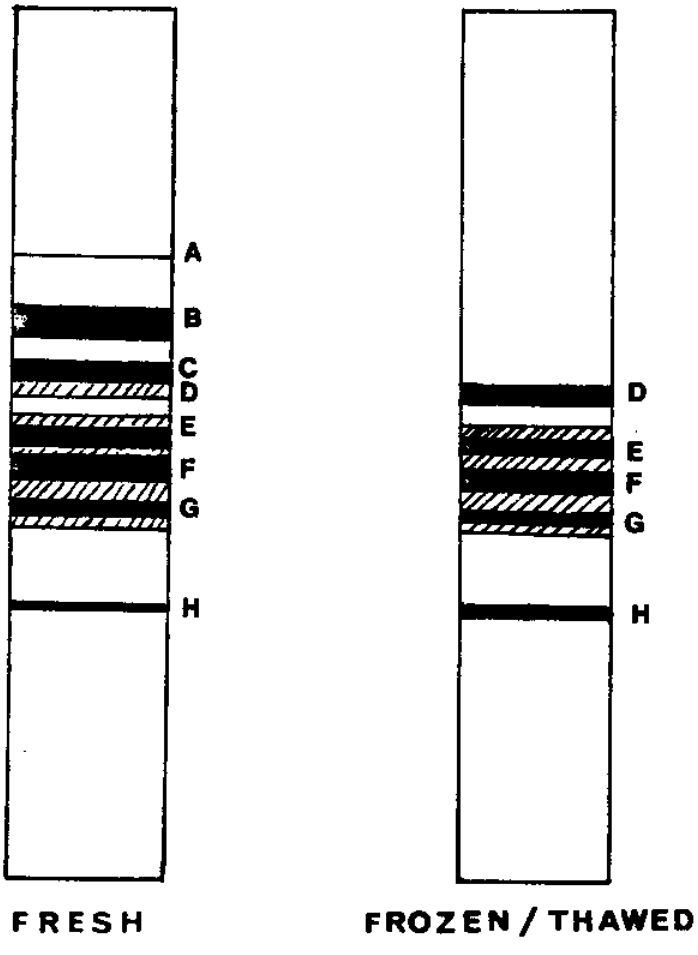
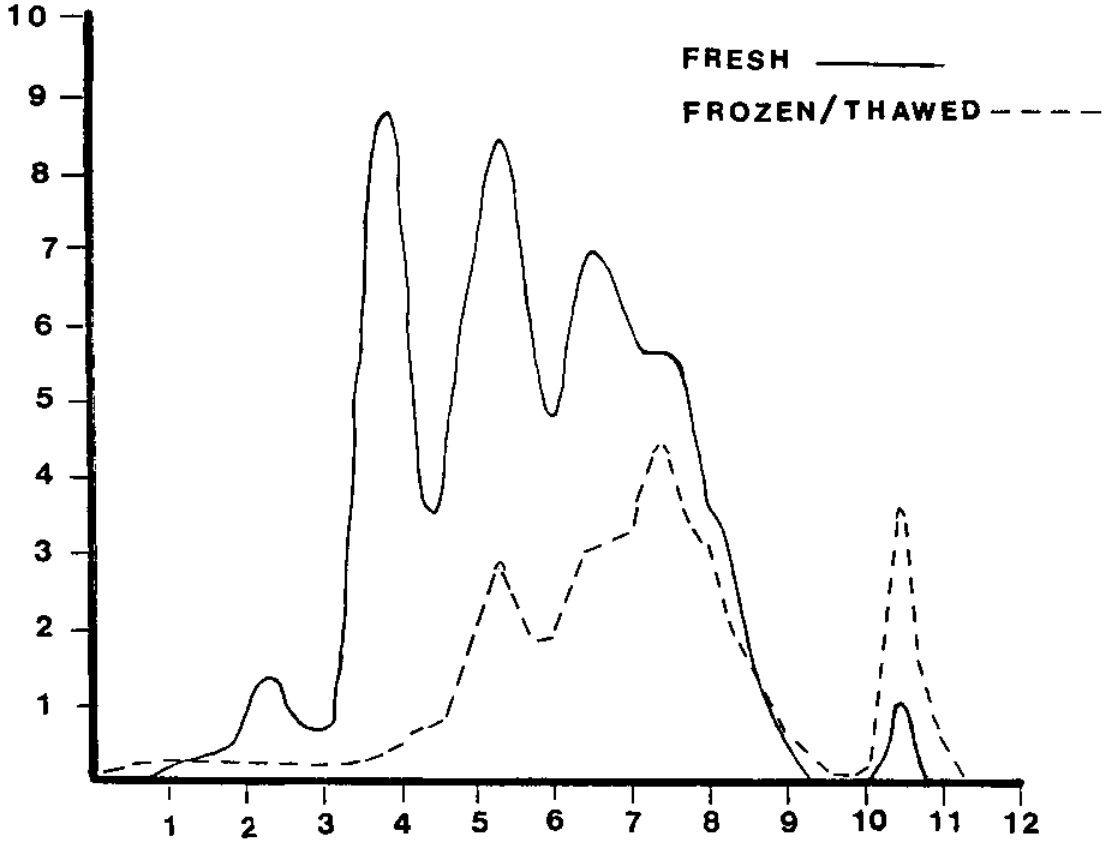


Figure 3

Densitometer Scans for Malate Dehydrogenase



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A PROGRESS REPORT ON THE PURIFICATION OF PHENOLOXIDASE FROM GULF SHRIMP

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INTRODUCTION

The changes we generally know as "black spot" in shrimp are highly detrimental to the shrimp marketing industry. The appearance of black spot does not affect flavor, odor or nutritional quality, but the change in appearance is very unappealing and may be enough to cause the rejection of the product by the consumer. Several seafood-oriented institutional buyers have set stringent rules regarding how much black spot can be allowed in the shrimp they buy.

Although black spot appearance is definitely time dependent, there seem to be other factors which may also influence this change. To understand these factors, it is important to consider what reactions in the live animal may be related to black spot formation. It has been reported (3) that, upon molting, crustaceans produce an orthoquinone, dopaquinone, from the amino acid tyrosine (Fig. 1). Orthoquinones have been shown to be involved in the process of sclerotization, or hardening, of the shell. There is also evidence of similar changes during wound repair processes (2), when the shrimp forms a new layer of shell to cover the exposed area.

Dopaquinone can also be further oxidized and polymerized to a compound called melanin, which is the black pigment we call black spot (Fig. 2).

Phenoloxidase, an enzyme naturally present in shrimp, effects the two initial reactions (Fig. 1). The first reaction is usually very slow, even in the presence of the enzyme. But after that, the reaction can proceed by itself under the right conditions.

Starting with this information, we designed several small experiments to test the enzyme, and to attempt inhibiting it. Currently, sodium bisulfite is widely used by shrimp fishermen as a dip to delay the onset of black spot. It is very effective when used properly, but it can also create unpleasant flavor or appearance or even health hazards if used improperly.

RESULTS AND DISCUSSION

The first goal was to purify the enzyme, to have it in a stable form. This step is mandatory, since any raw extracts of shrimp tend to darken very quickly. Heads of shrimp were used as raw material, as they are relatively easier to extract. The procedure for the initial extraction is described in Fig. 3.

The acetone extraction removes a good amount of lipid material and the extracts made from acetone powder are completely transparent, but on standing it will turn dark; this is possibly due to residual DOPA or

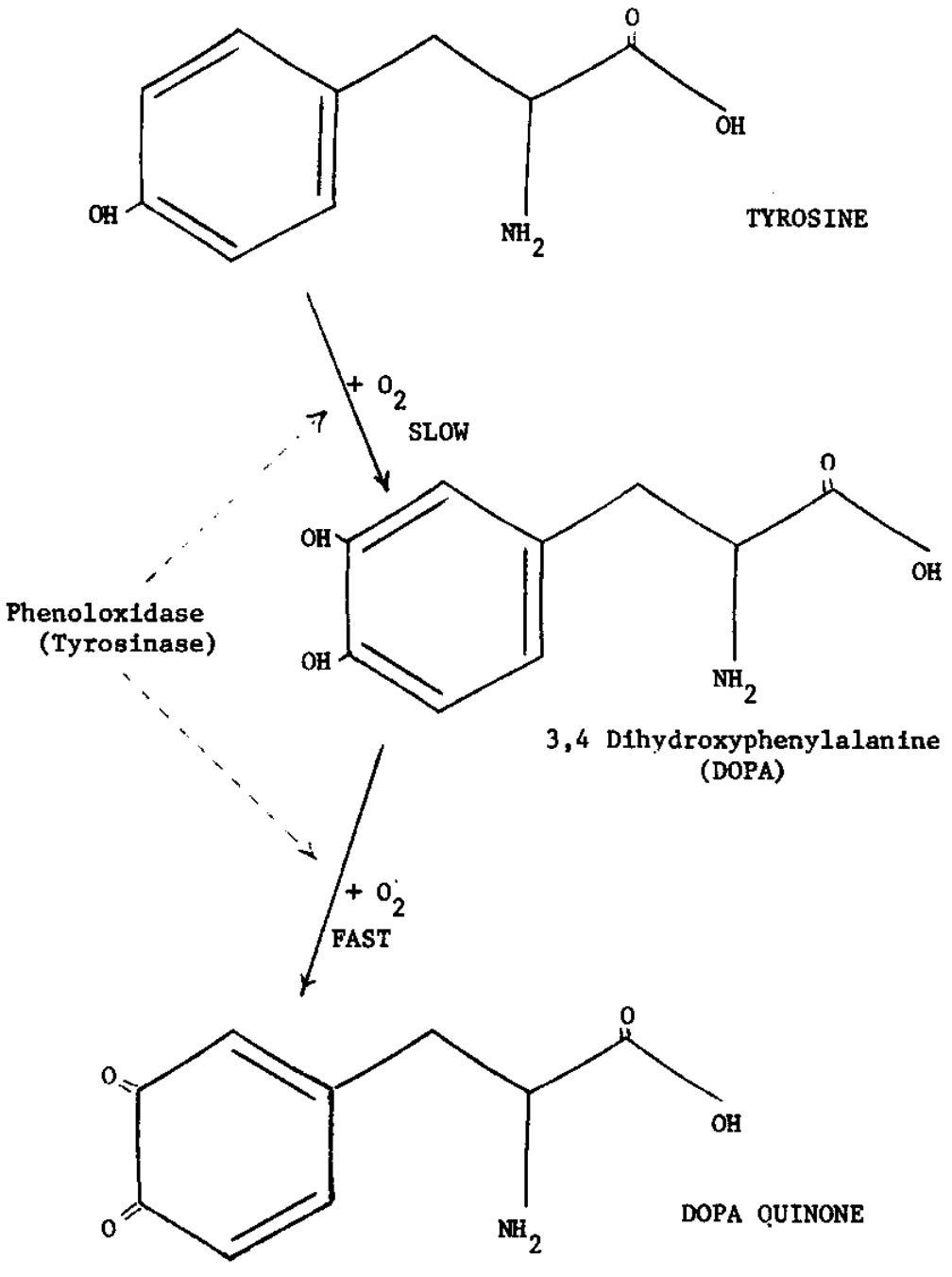
O
OH
OH
NH2
TYROSINE
+ O2
SLOW
Phenoloxidase
(Tyrosinase)
O
OH
OH
OH
NH2
3,4 Dihydroxyphenylalanine
(DOPA)
+ O2
FAST
O
O
O
OH
NH2
DOPA QUINONE

Figure 1

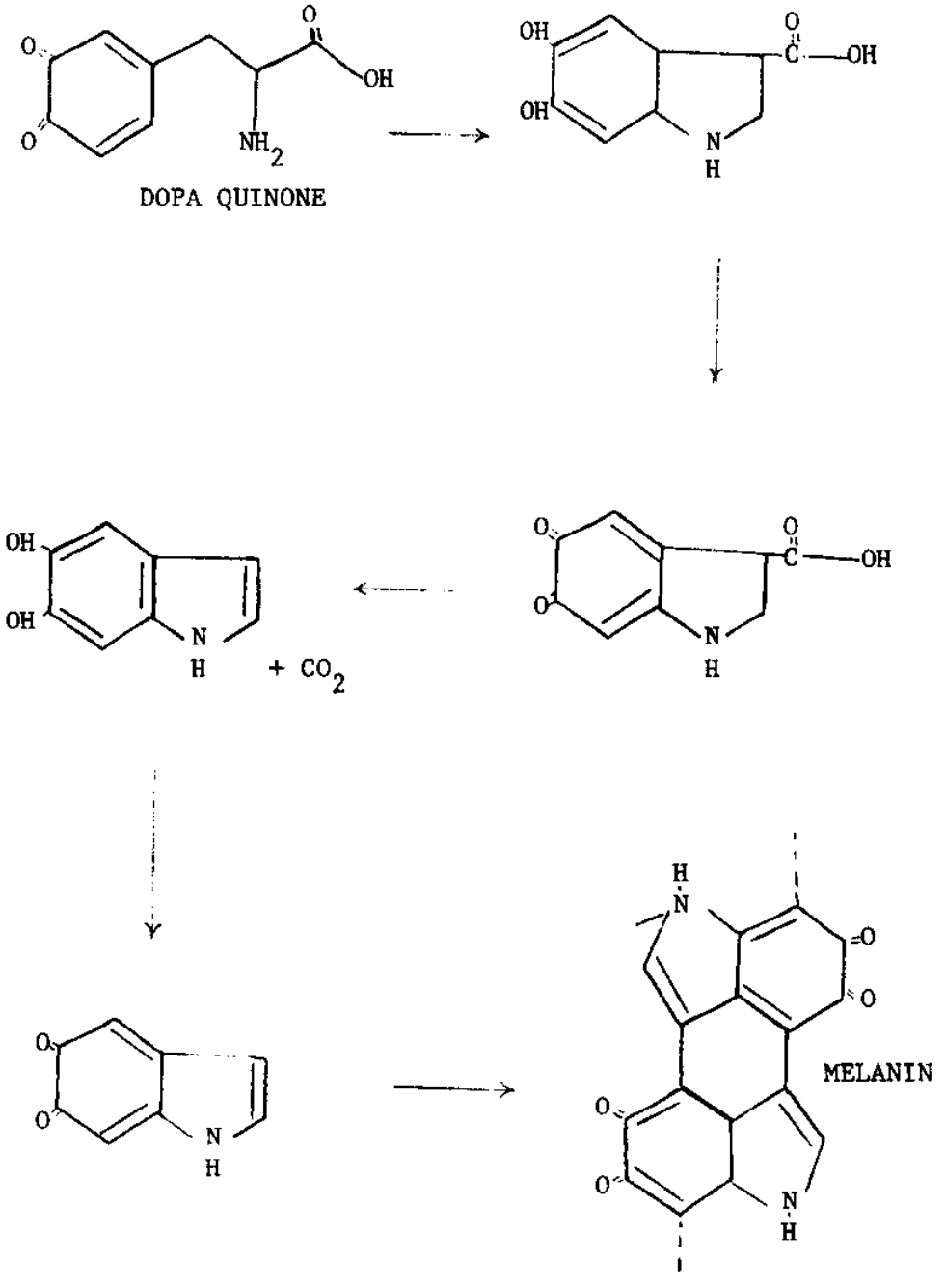

Figure 2

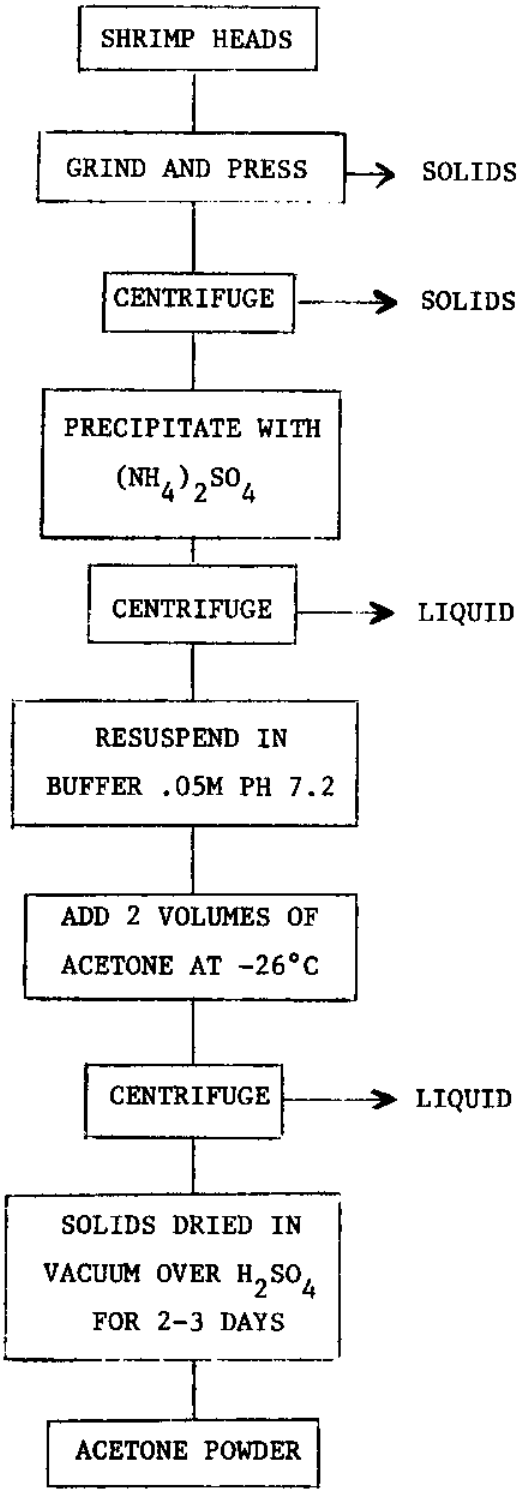
SHRIMP HEADS
GRIND AND PRESS
SOLIDS
CENTRIFUGE
SOLIDS
PRECIPITATE WITH
$(NH_4)_2SO_4$
CENTRIFUGE
LIQUID
RESUSPEND IN
BUFFER .05M PH 7.2
ADD 2 VOLUMES OF
ACETONE AT -26°C
CENTRIFUGE
LIQUID
SOLIDS DRIED IN
VACUUM OVER H_2SO_4
FOR 2-3 DAYS
ACETONE POWDER

Figure 3

to the activity of proteolytic enzymes which release free tyrosine into the medium.

For further purification, gel filtration has been used. This procedure separates molecules depending on their size. The results from this test show that the enzyme is a very heavy molecule. The exact molecular weight has not yet been determined. The enzyme solutions obtained after gel filtration are colorless, and stable in refrigeration.

Another observation gathered from this test is that the reaction from DOPA to melanin is accelerated by increases in pH. Past research in this laboratory (4) has shown that the pH in the surface of the shrimp increased during ice storage. Other authors have reported that shrimp with surface pH as high as 8.2 (1) is still edible. At this pH, a solution of pure DOPA turns black in a matter of minutes, without the need of the enzyme. So pH very possibly is also a factor in effecting black spot formation in shrimp. Exposure to daylight also accelerates the oxidation of DOPA in vitro.

It is important to gather enough information about the enzyme and the reaction, to be able to approach the inhibition from a better standpoint. Once the enzyme is purified, tests will be conducted with compounds which may have inhibitory properties. The effect of temperature and light will also be tested.

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QUALITY CHANGES DURING ICED STORAGE OF WHOLE FRESHWATER PRAWNS (Macrobrachium rosenbergii)

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The culturing and production of freshwater prawns (Macrobrachium rosenbergii) is rapidly emerging from the experimental stage into full-scale commercialization, and the species should soon take its place among other successful aquaculture enterprises such as salmon, trout, catfish and oysters. Harvesting statistics for freshwater prawns are sparse; however, in the state of Hawaii alone, annual production increased from 4,000 pounds in 1972 to 176,400 pounds through October 1979 (Lee, 1979). Production for 1979 was estimated to be in excess of 250,000 pounds but was much less than expected due to unusually cold weather which limited the supply of juveniles for stocking. The Hawaiian Prawn Producers Association estimates the 1981 production will be near 900,000 pounds. (Total U.S. landings for all marine shrimp species was approximately 336 million pounds for 1979 (USDC, 1979).)

Pioneering efforts in the breeding and culture of freshwater prawns began with the work of Shao Wen Ling in Penang, Malaysia, in 1959 and was continued by Takuji Fujimura in Hawaii (Meyers, 1974; Lee, 1979; Goodwin and Hanson, 1974). Since that time, most of the research effort has focused on hatchery and grow-out phases of production (Nip and Moy, 1979) and this phase of commercialization is now fairly well-defined. The next logical step is to concentrate on evaluating post-harvest handling methods and product quality parameters.

Although the results of a few studies have been reported, proper handling methods, maintenance of product quality and optimum storage conditions for harvested prawns have not been adequately addressed. Reports that are available reveal that research on product quality has been directed toward evaluating stability of the prawns during frozen storage (Nip and Moy, 1979; Miyajima and Cobb, 1977; Reddy, Nip and Tang, 1981; Hale and Waters (1981)). Reports on the shelf life of iced freshwater prawns will keep on ice only 3 to 4 days before deterioration begins (Hanson and Goodwin, 1977; Miyajima and Cobb, 1977; Nip and Moy, 1979; Lee, 1979) but the actual data have not been reported in the literature. These workers suggest that the prawn hepatopancreas is extremely active enzymatically, and is chiefly responsible for the mushiness that develops during iced storage. Mushiness of the tail muscle is suggested as being the major factor contributing to the relatively short shelf life of whole iced prawns (Hanson and Goodwin, 1977; Goodwin and Hanson, 1974). Blanching at 65°C (150°F) for 15 seconds after chill-killing is reported to extend the shelf life to 4 to 6 days (Nip and Moy, 1979).

Iced storage is a convenient method of short-term preservation of prawns destined for market outlets in relatively close proximity to the

supply and the practice will probably continue as production increases. The shelf life of ice-stored whole prawns needs to be better defined and if it is only 3 to 4 days as reported, additional methods are needed to increase it substantially. The objectives of this study were to determine the shelf life of whole prawns held on ice (1) untreated, (2) blanched at 65°C (150°F) for 15 seconds and (3) dipped in a 50 ppm solution of chlorine for 1 minute. The latter two methods were selected because of previous reports of their effectiveness.

MATERIALS AND METHODS

Materials

Freshwater prawns were harvested from experimental ponds by South Carolina Marine Resources Research Institute (MRRI) personnel, spray-washed and chill-killed by immersion in ice water. They were transported to the laboratory in ice water tanks. Experimental samples were removed, mixed with flaked ice and refrigerated overnight. The prawns were processed approximately 18 hours after harvest. The average size of the whole prawns was 38 g or about 12 count per pound.

Thirty-nine pounds of whole prawns were removed from the ice and sub-divided into three equal groups of 13 lb. each. The first group was placed on ice and served as the control. The second group was immersed (in mass) in 40 gallons of water at 65°C (150°F) for 15 seconds, cooled for 1 minute in ice water and placed on ice. The third group was immersed in a 50 ppm chlorine solution (sodium hypochlorite) for 1 minute, drained and placed on ice. The three groups were iced in plastic containers (with provisions for the ice-melt to drain off as formed) and placed in a cooler at 4°C (39°F). The prawns/ice ratio was maintained at about one/one during the 20-day storage period. Representative samples of each treatment were removed at regular intervals and evaluated for total volatile nitrogen, pH, total aerobic plate count and sensory values. Peeled, raw meats from at least three prawns, or portions thereof, were used as subsamples in the microbial and chemical analyses of all sample treatments.

Methods

Chemical Analyses --- Total volatile nitrogen (TVN) analyses were conducted using the modified Conway microdiffusion technique described by Obrink (1955) and further modified by Cobb *et al.* (1973). The results are reported as an average of three replicates. The pH was measured by direct contact of a combination pH electrode with the raw, macerated flesh.

Microbial Analyses --- The microbial analyses consisted of determining the total aerobic plate count (TAPC) following procedures outlined in FDA's Bacteriological Analytical Manual for Foods (AOAC, 1976). Standard plate count agar was used as the plating medium and the plates were incubated at 22°C (72°F) for 5 days. TAPC is reported per gram of sample and the results are the average of three replicates.

Sensory Evaluations --- All prawn samples were peeled, deveined and cooked by boiling for 2 minutes in 2% saltwater. They were then rinsed with cold water and refrigerated for 2 hours before presentation

to the taste panelists. Organoleptic evaluations were made by six panelists at zero, 4, 6, 8, 11, 14 and 18 days of iced storage. Evaluations of color (light to dark), odor, flavor (mild to strong), texture (soft to firm) and acceptability (reject to accept) were recorded by each panelist by placing a vertical slash mark on a 200 mm long open scale line.

RESULTS AND DISCUSSION

Chemical and Microbiological Evaluations

The results of analyses for TVN, TAPC and pH are shown in Table 1. The TVN values for all treatments remained relatively unchanged throughout storage, although some fluctuation did occur. Analysis of variance (ANOVA) showed that there were significant differences in TVN ($P \leq 0.05$) among treatments at 14 and 18 days of storage. TVN values for the chlorine-dipped and blanched samples were significantly higher than the controls at days 14 and 18. No explanation for this unexpected occurrence is offered. The lack of an overall increase in TVN values during storage indicated repression or lack of a significant number of proteolytic microorganisms and/or the absence of inherent proteolytic enzymes.

The initial TVN values for all treatments were substantially higher than those reported for penaeids (Cobb et al. 1973) and those reported for fresh water prawns in an earlier study by Hale and Waters (1981). The initial values (27-29.5 mg N/100g), in fact, correspond to those observed in penaeids held on ice for 15-18 days and characterized as spoiled. Values reported in this study, however, agree with those reported by Miyajima and Cobb (1977). A re-examination of prawns harvested in February 1981 from culture tanks at the South Carolina MRRI produced TVN values of 23-24 mg N/100 g of sample. The difference in TVN values for penaeids and freshwater prawns may be attributed to differences in feed ingredients, season of harvest, and/or environmental grow-out conditions for freshwater prawns.

The pH of prawns for all treatments increased progressively from 7.20 initially to a high of 7.75 for the control at 20 days of storage. The relatively slight increase in pH during storage indicates minimal breakdown of proteins releasing ammonia and amines and is reflected in the values obtained for TVN. The initial pH values found in this study correspond to those reported for ice-stored penaeids (Flores and Crawford, 1973). Our reported values agree with those of Nip and Moy (1979) but are higher than those shown by Hale and Waters (1981). Values reported for ice-stored penaeids increased from 7.2 to about 8.2 after 20 days and from 7.5 to about 8.5 for pandalids after 8 days of storage. Bailey et al. (1956) suggested that a pH of 7.7 or below is indicative of prime quality shrimp; those having values from 7.7 to 7.95 are poor quality but acceptable, and those having a pH of 7.95 or above were characterized as spoiled.

The TAPC for all treatments increased steadily during storage. Statistical analysis (ANOVA) showed that significant differences exist among treatments only on days 14 and 18. The TAPC increased through

Table 1. Total volatile nitrogen (TVN), pH and total aerobic plate count (TAPC) of ice-stored freshwater prawns.

STORAGE PERIOD (DAYS)	TREATMENT	TVN (mg N/100g)	pH	TAPC (Log No./g)
0	Control	26.76	7.20	4.79
	Cl_2 dipped	29.44	----	5.03
	Blanched	26.78	----	4.90
5	Control	----	7.20	----
	Cl_2 dipped	----	7.20	----
	Blanched	----	7.25	----
6	Control	28.95	----	5.38
	Cl_2 dipped	26.88	----	4.67
	Blanched	29.11	----	4.75
8	Control	30.74	7.30	4.96
	Cl_2 dipped	30.47	7.25	5.57
	Blanched	28.51	7.30	4.28
11	Control	26.58	----	5.81
	Cl_2 dipped	26.01	----	5.30
	Blanched	27.14	----	5.83
14	Control	22.98	7.50	7.45
	Cl_2 dipped	28.96	7.40	6.49
	Blanched	29.79	7.45	6.57
18	Control	21.51	7.65	8.08
	Cl_2 dipped	27.92	7.50	7.68
	Blanched	26.04	7.60	7.32
20	Control	29.74	7.75	8.16
	Cl_2 dipped	29.22	----	8.18
	Blanched	----	----	8.02

about 3 log cycles (log 5 to 10g 8) with the control leading slightly after 11 days of storage. Flores and Crawford (1973) showed that the TAPC for ice-stored penaeids increased 2.5 logs after 10 days of storage and increased correspondly with the pH. Alvarez and Koburger (1979) and Koburger et al. (1973), reporting on the iced storage of penaeids, showed an increase in TAPC of 2.5 logs after 10 days and 3 logs after 14 days of storage, respectively. Bieler et al. (1972) showed that the TAPC for rock shrimp (Sicyonia brevirostris) increased about 2.5 logs after 14 days of ice storage.

Sensory evaluations of each sample at each storage time were quantified on the 200mm open scales. Analysis of variance was performed on the numberical data to determine significant differences among treatments. The average color scores of the six panelists for each treatment and time are exhibited in Figure 1. There was a general upward trend in color (darker) through 18 days of iced storage. The results indicated that the

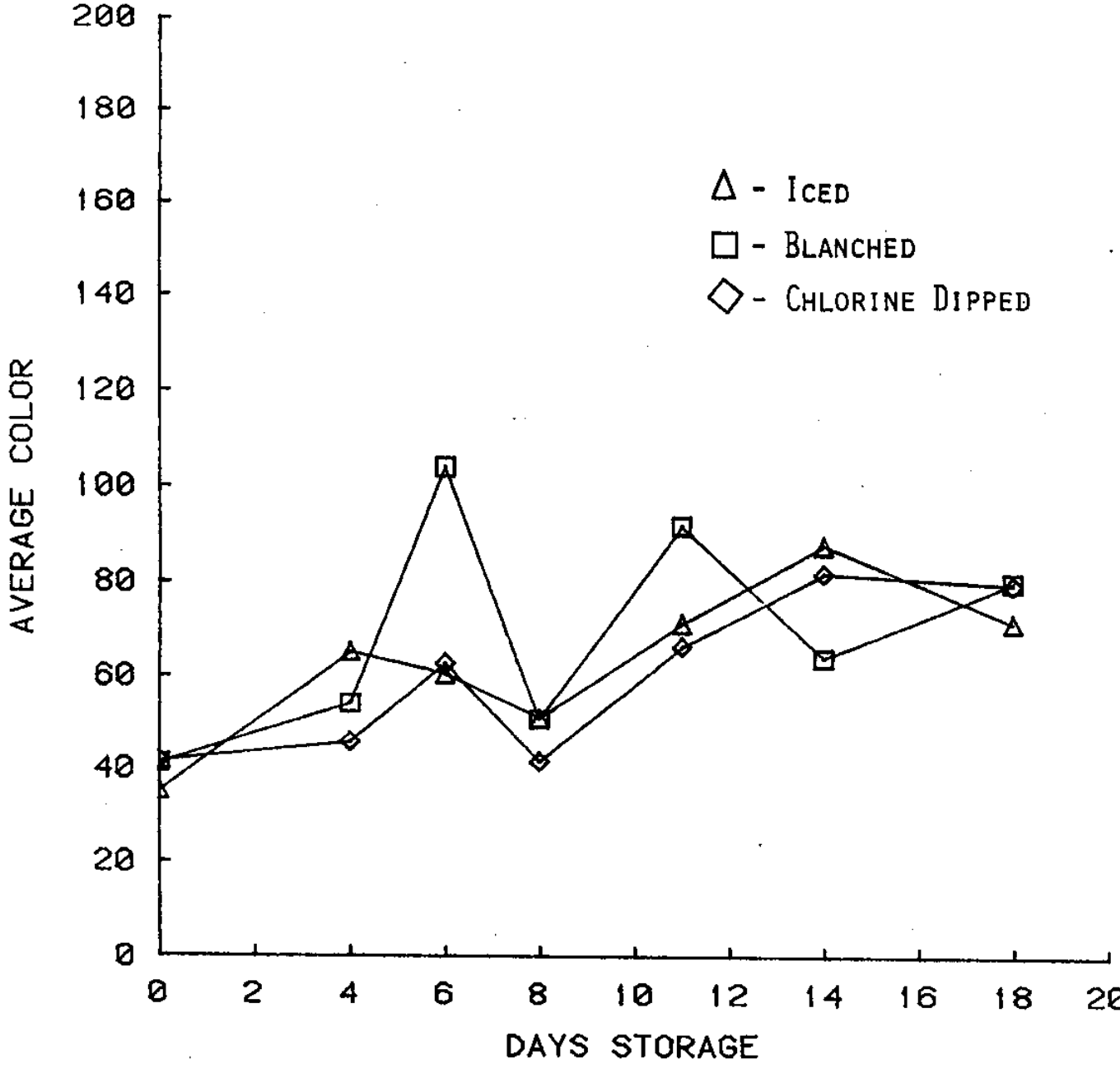

Figure 1. Average color intensity at each storage period.

blanched sample was significantly darker than the control and chlorine dipped samples at 6 days but no significant difference was found at other time periods.

The average odor scores are shown in Figure 2. There was a steady increase in odor intensity of the cooked samples with no significant differences between treatments. Average flavor scores appear in Figure 3. There was a general increase in flavor intensity, accelerating after 14 days of storage. The treatments were significantly different ($P \leq 0.05$) at day 6 only.

The average texture (firmness) ratings are shown in Figure 4. The results were variable and showed no real change in texture after 18 days but all samples were softer at 4 days than at zero, 6 or 8 days, and the blanched sample was softer than the others at 8 days. Mechanical shear values were determined for zero and 4-day iced samples (control) only as part of another study. The average values as measured with the Kramer shear press on 100 g samples were 372 lb force at zero time and 225 lb force at 4 days, a 40% decrease in force.

Average acceptability ratings of the panelists are shown in Figure 5. Acceptability was rated on personal preference considering all rating factors. There was a general downward trend in acceptability over the 18-day storage period, but the blanched and chlorine dipped samples recovered after a sharp decline over the first 4 days and then resumed a more gradual decline after 8 days. This is probably related to the perceived mushy texture of the experimental samples at 4 days followed by firmer texture ratings. Both experimental samples were significantly lower in acceptability than the iced control at 4 days ($P \leq 0.01$), and the blanched sample was significantly less acceptable than the control and chlorine dipped samples ($P \leq 0.05$) at 8 days.

CONCLUSIONS

In general, treatment of freshwater prawns with a 1-minute chlorine dip (50 ppm) or with a 15-second blanch at 65°C (150°F) did not substantially increase the iced storage life. Although chlorine and blanching treatments slightly delayed an increase in pH beyond 8 days of storage, the TVN values were not appreciably different from the control. Chlorine-dip and blanching treatments significantly inhibited the TAPC at 14 and 18 days as compared to the control. The relatively unchanged TVN values and minimal increase in pH indicated little proteolysis during storage. Apparently the proteolytic enzymes (except perhaps the collagenases), either inherent or microbially produced, remain inactive or react very slowly at ice storage temperatures. Although the TAPC increased at a constant rate, the population may not have included proteolytic microorganisms. Slight spoilage odors of the raw prawns were noted at 14 days of storage as reported by an informal panel of three technologists and were evident among all treatments. Mushiness of the raw tail muscle was observed on the 11th day for all treatments.

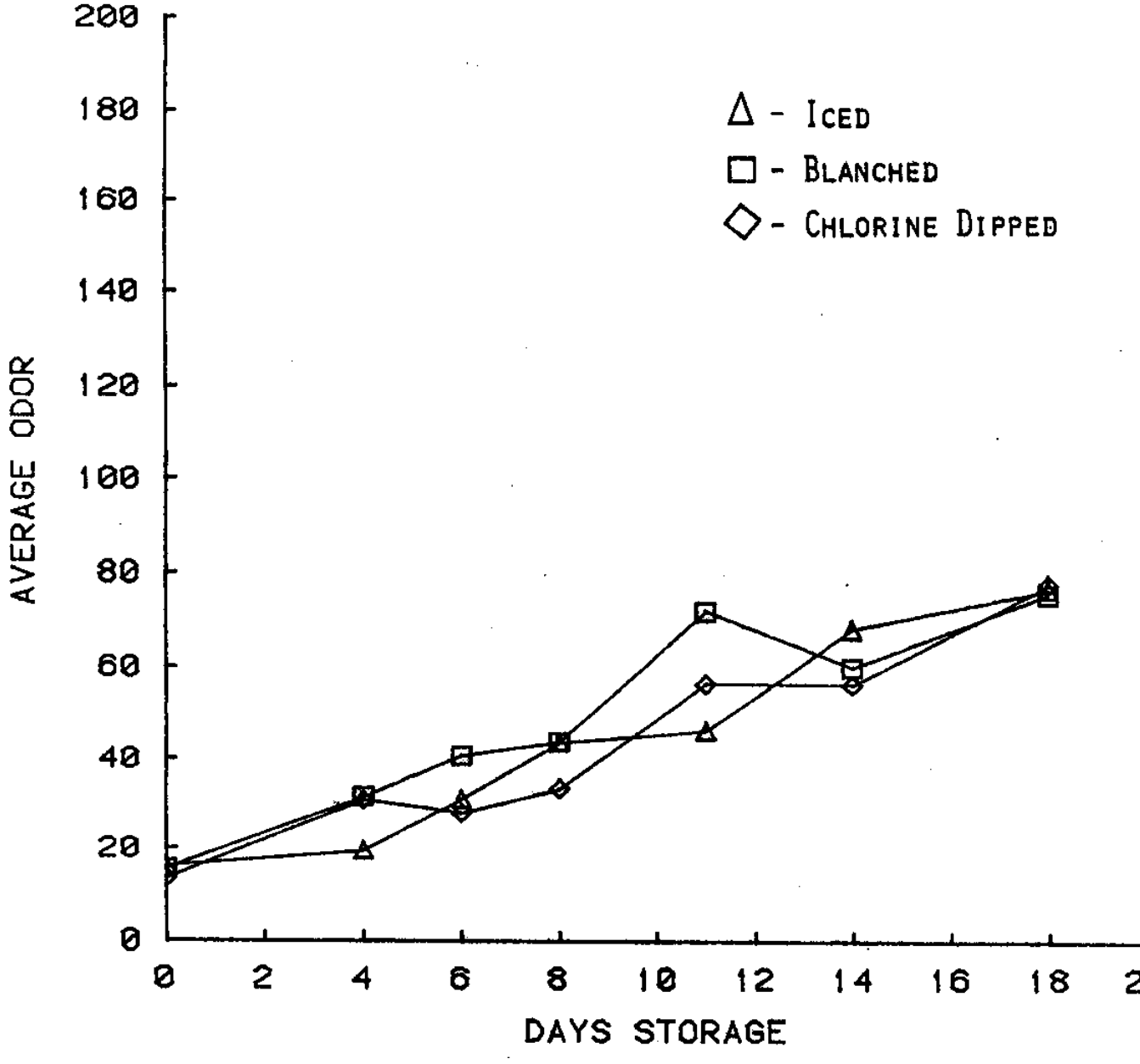

Figure 2. Average odor intensity at each storage period.

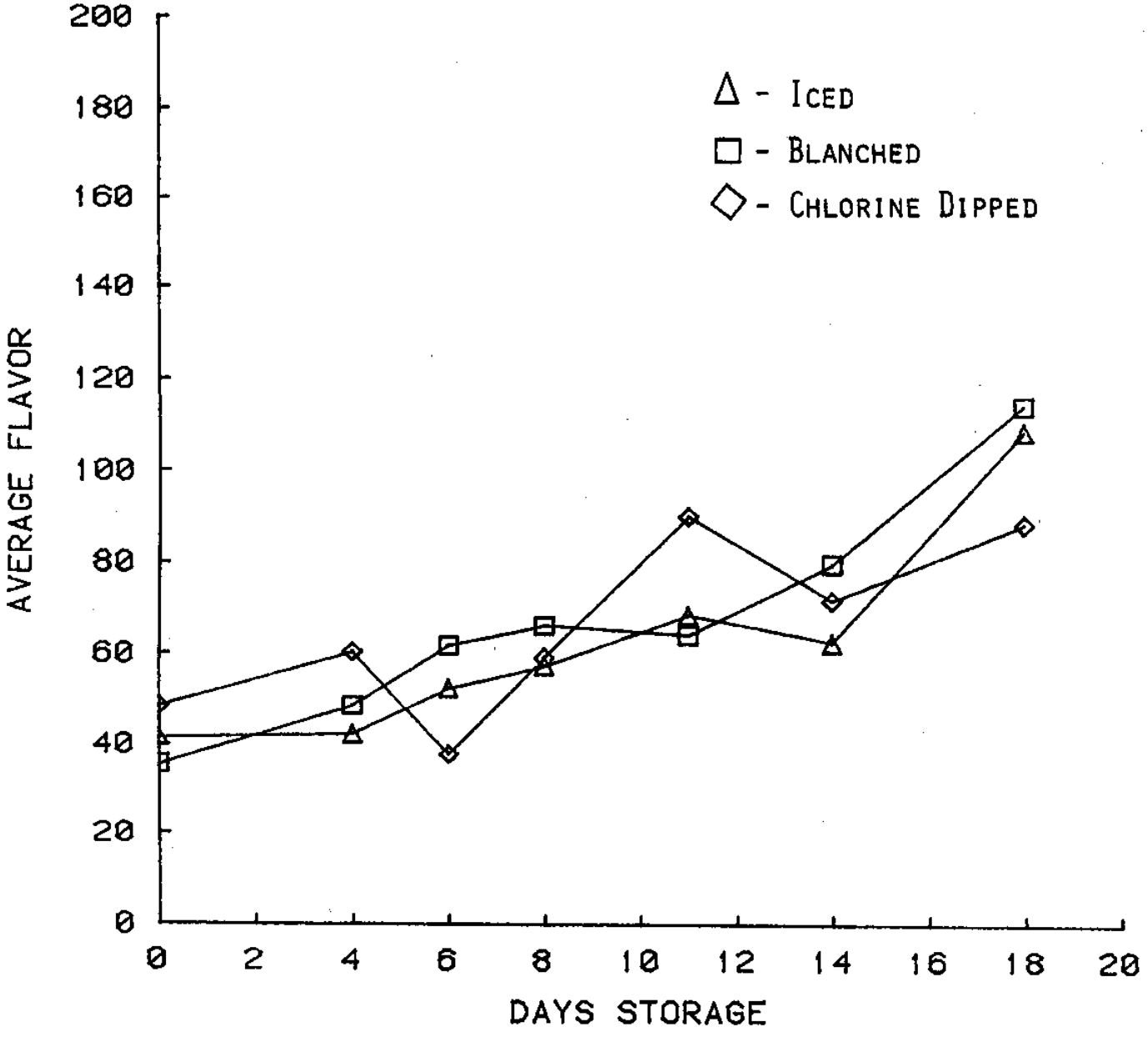

Figure 3. Average flavor intensity at each storage period.

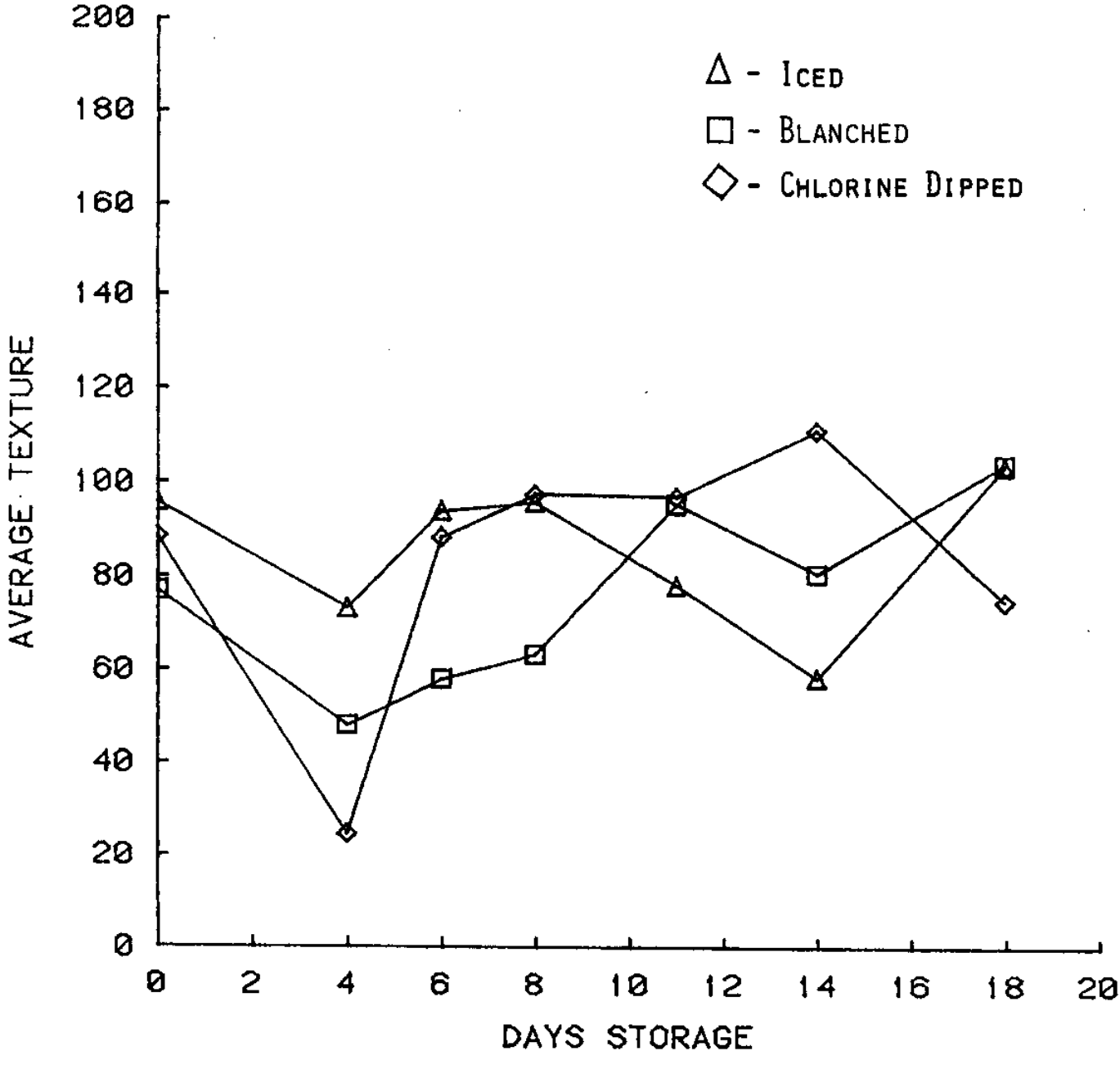

Figure 4. Average texture at each storage period.

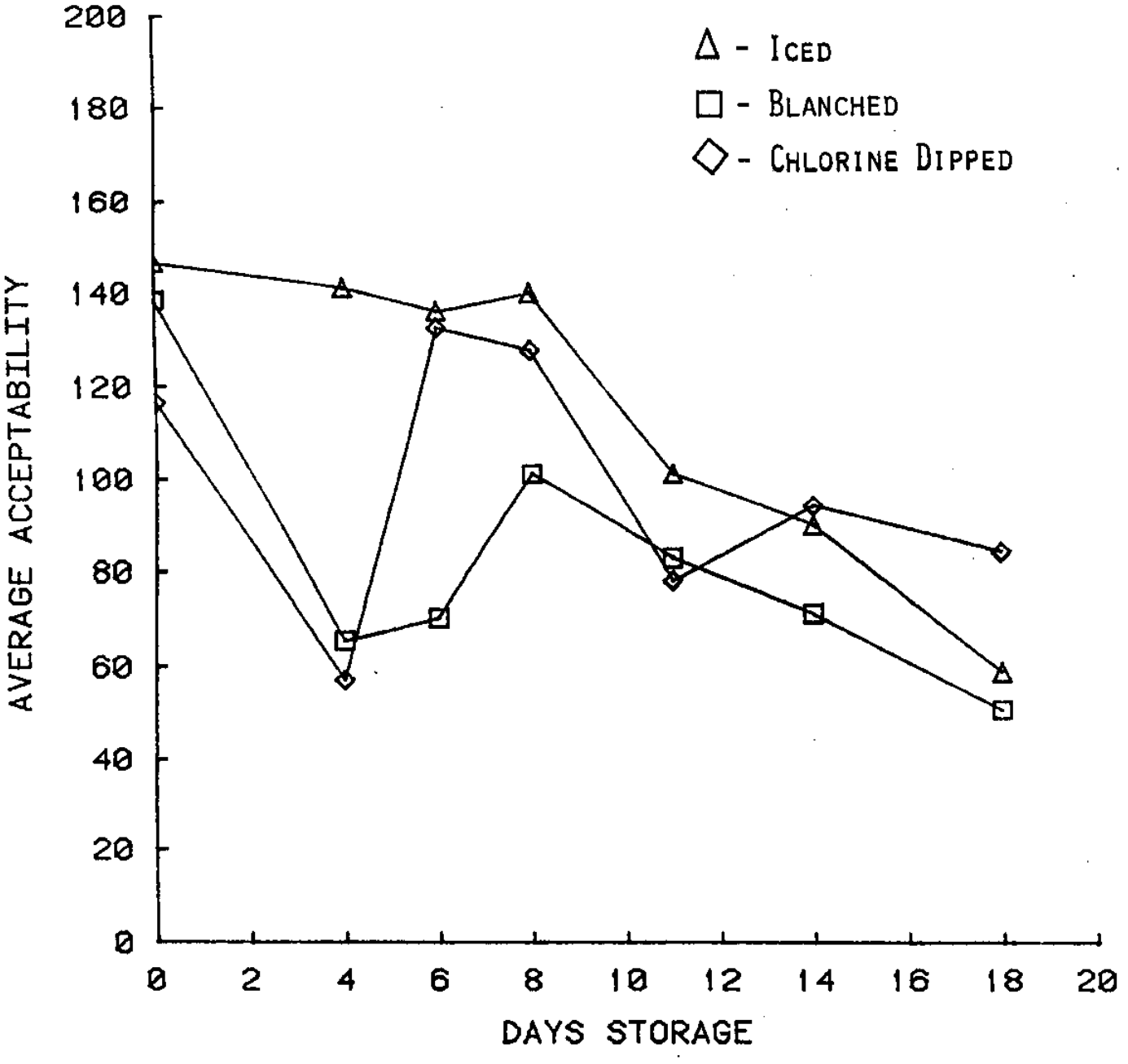

Figure 5. Average acceptability at each storage period.

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DEVELOPMENT OF AN ENZYME AFFINITY ASSAY FOR SEAFOOD PRODUCTS

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Various methods have been developed to ascertain the quality of fish and fishery products. Organoleptic examination by trained inspectors is the most common method to evaluate seafood quality. Although this method is rapid and inexpensive, it is only semi-quantitative, but even trained inspectors often disagree as to what is unacceptable. In addition to being subjective, such tests rely upon the taste and odor of compounds that may be unrelated to the materials that are actually toxic, since toxic compounds in many cases have no taste or odor of their own. Thus, more quantitative, objective methods of evaluation are sought after by both the fishing industry and the consumer.

As early as 1937 Beatty and Gibbons (1) developed a technique to quantitate volatile amines, and demonstrated that the concentration of these amines could be correlated to decomposition in seafood. Bailey et al. (2) indicate that fish spoilage is derived from metabolic changes in tissue (autolytic changes), autooxidative processes, and bacterial action. Most investigators believe that bacterial enzymes are the major cause of spoilage.

Histamine, derived from the bacterial decarboxylation of the amino acid histidine has been implicated in the type of food poisoning known as scrombroid poisoning. Scrombroid poisoning is characterized by symptoms resembling those of histamine toxicity: flushing, palpitation, headache, and/or gastrointestinal upset. Although consumption of as much as 20 mg of pure histamine failed to produce these symptoms, its presence has been noted in spoiled fish and as a result an amount in excess of 50 mg percent is considered unsafe in food products (3).

A variety of chemical, biological and isotopic methods have been used to assay histamine. The lack of useful light absorption or emission properties requires that chemical analysis be based upon the properties of derivatives. Pure histamine in solution may be quantitated by various chemical methods, but the assay of biological samples usually requires purification before any chemical determination can be satisfactorily applied. The quantitative determination of histamine by coupling to a diazotized aromatic amine was first reported by Weiss and Ssobolew in 1914 (4). Koessler and Hanke (5) were first to use this reaction preceded by purification for the quantitative determination of histamine and imidazoles in general.

Diazo coupling methods have two major obstacles to overcome: the instability of the colored product and the nonspecificity of the reaction (6). The achievement of adequate specificity is usually achieved by prior extraction of histamine either by chemical or chromographic

methods. The colored product can be partially stabilized with an adequate buffer followed by extraction of the product into methyl isobutyl ketone; however, the light absorption decreases by 7% per hour (7). This has been the accepted A.O.A.C. method until the development of the more specific phthalaldehyde procedure (8,9).

In 1959, Shore, Burkhalter and Cohn (10) observed that ortho-phthalaldehyde would condense with histamine under alkaline conditions. When the product is activated at 350 nm at low pH, it fluoresces at 450 nm with an intensity proportional to the histamine concentration. The reaction is of sufficient specificity that purification of the histamine derivative is not usually necessary -- an advantage over other chemical methods. As with the diazo method, the stability of the derivative has been questioned.

During the past 10 to 15 years, immunoassays have gained wide acceptance as the method of choice for the routine analysis of a wide variety of substances because of their specificity, sensitivity, and relative ease. Such assays include radioimmunoassay (RIA), immuno-fluorescence and more recently enzyme-linked immunosorbent assay (ELISA) (11,12). In each case the most essential part of the assay is the availability of an antibody that is capable of specifically binding the toxin.

Although there are many modifications, ELISA techniques usually involve competition between the toxin in the sample and a known amount of toxin-enzyme conjugate for antibody binding sites. As a result of this competition, the amount of conjugate that binds to the antibody is inversely proportional to the amount of toxin in the sample. After separation of bound and unbound conjugate, the enzymatic activity of the bound conjugate is measured colorimetrically.

Antibody to histamine has been reported by various authors (13,14, 15,16). However, other investigators have not succeeded in obtaining useful quantities; in some cases injection of antigenic compounds may result in increased production of amine oxidases in the test animals. Both monoamine and diamine oxidase are physiologically capable of exerting a protective role against histamine (17,18).

For this reason, a substitute for histamine antibody was sought. Various proteins which are known to be capable of binding histamine are shown in Table 1. Of these, hog kidney diamine oxidase (DAO) was chosen because of its relative specificity and availability.

TABLE 1. Proteins Capable of Binding Histamine

Antibodies	Not yet isolated
H_1 and H_2 cell receptors	Not yet isolated
Enzymes	
N-methyl transferase (NMT)	Highly specific; not commercially available
monoamine ozidase (MAO)	Not specific; commercially available; unstable
diamine oxidase (DAO)	Relatively specific; commercially available; stable

DAO catalyzes the reaction shown in Figure 1. Crabbe and Bardsly (19) have shown that this enzyme reacts by a Ping Pong Bi-Ter mechanism with initial binding to the diamine. The deamination reaction, however, is quite slow compared to the initial binding; it requires four milligrams of commercial DAO to deaminate one micromole of histamine in one hour. Thus a negligible amount of histamine is deaminated during the three-minute duration of the assay. Of course, DAO will bind but not react with histamine conjugates in which the histamine moiety is converted to an amide or a secondary amine.

When the rate of binding by an enzyme is large compared to the rate of catalysis, the dissociation constant k_{-1}/k_1 is approximately equal to k_m. The k_m value for DAO is 6.5×10^{-5} at pH 7.4 (20). This can be compared to a dissociation constant of 10^{-5} for most hapten-antibody reactions (21). In other words, in the event that antibody to histamine should be obtained, it most likely would not bind better than DAO.

METHODS AND MATERIALS

ELISA type histamine assay employing DAO Reagents

1. Histamine binding tubes. Kimble 12 x 75 mm polystyrene culture tubes were incubated with 5 mg DAO (Sigma) in 2 ml distilled/deionized water at room temperature for varying periods of time. The contents were then poured off and the tubes incubated an additional 15 minutes with 5 mg/2 ml bovine serum albumin to reduce non-specific binding. The tubes were then rinsed five times to remove unattached protein.

2. Histamine-perioxidase conjugate. Histamine dihydrochloride (100 mg) and horseradish peroxidase (Sigma, 100 mg) were dissolved in 1 ml water, then reacted for 30 min. with 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide HCl (600 mg). After dializing 24 hours, the product was lyophilized, and 0.05 mg/ml was dissolved in 0.01 M pH 6.5 phosphate buffer.

3. Dye solution. Ortho-dianisidine (0.3 mg/ml) was dissolved in 0.01 M pH 4.0 citrate buffer. Hydrogen peroxide (20 microliter/ml 3%) was added to the dye solution shortly before use.

4. Stopping solution. Six molar sulfuric acid was used to stop all enzymatic reactions.

Assay procedure

One ml of sample solution containing histamine was mixed with one ml histamine-peroxidase conjugate. This mixture was incubated in a histamine binding tube for 3 min. The mixture was then poured off and the histamine binding tube rinsed 5 times with distilled water. Two ml of dye solution was added to the tube. After 2½ min., the reaction was stopped by adding 2 ml of the stopping solution. The absorbance was then measured at 480 nm and compared to a standard curve.

Histamine-inhibition precipitation reaction reagents

1. Histamine-binding suspension. Carboxymethylcellulose hydrazide (200 mg) was converted to CM-cellulose azide by the addition of 5 ml 2.5% HCl followed by 10 mg $NaNO_2$. The precipitate was washed in cold water and again in 0.05 M phosphate buffer at pH 8.7. The cellulose derivative was then reacted with 10 mg DAO dissolved

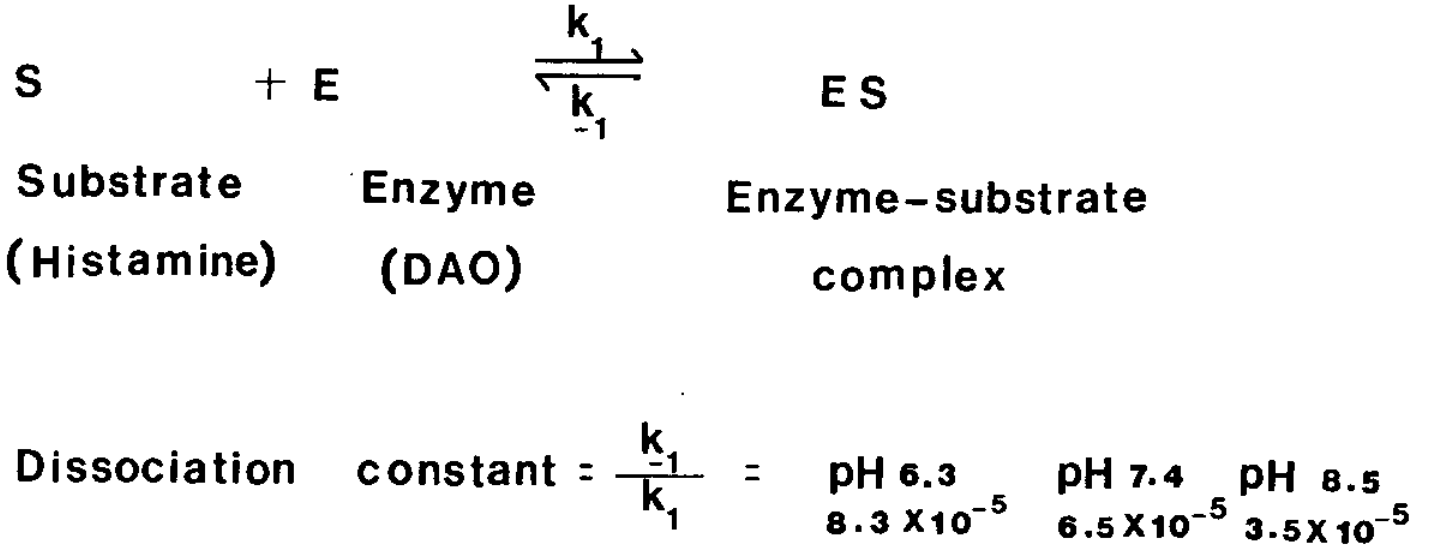


FIGURE 1. Effect of pH on Binding Constants for Diamine Oxidase

in 5 ml of the same phosphate buffer. After the reaction, the conjugate was washed and lyophilized.

2. Precipitating reagent. Bovine serum albumin (100 mg) and histamine dihydrochloride (100 mg) were dissolved in 1 ml water, then reacted for 30 min. with 1-ethyl-3-(3-dimethylaminopropyl carbodiimide HCl (600mg). The product was dialized 24 hours and lyophilized.

Assay procedure

1. Approximately 5 mg of the AO-cellulose conjugate were dissolved in 3 ml water forming a colloidal suspension having a milky appearance. To this suspension was added the sample containing histamine.

2. One-tenth ml of a 1 mg/ml solution of the precipitating reagent was added to the above mixture. In the absence of sample histamine, the suspension had very noticeable clumping followed by precipitation.

RESULTS AND DISCUSSION

Variable amounts of diamine oxidase or other protein can be attached to polystyrene tubes by changing the surface area, pH, and incubation time. Figure 2 shows the effect of incubation time compared to the DAO binding activity of the tubes. Some of the enzyme denatured or was destroyed by bacterial action after 200 hours. By regulating the number of binding sites on the tubes, one can change the sensitivity of the reaction.

Histamine-protein conjugates have been prepared using a variety of bifunctional reagents. These have included diazotized para-aminoacetanilide (14), glutaraldehyde followed by sodium borohydride (22), oxidation of protein-bound carbohydrate to vicinal aldehydes (23), 1-ethyl-3-(3-dimethyl-aminopropyl) carbodiimide HCl (CDI) (24), and others (25). CDI forms amide bonds between free carboxyl groups on the protein and a primary amine. This method of conjugation has been found to be reliable and does not prevent bound histamine from binding to DAO or destroy appreciable peroxidase activity. CDI conjugates of bovine serum albumin have been prepared containing up to 11% histamine, determined by the incorporation of tritiated histamine.

Evaluation of the various parameters affecting this assay method are presented separately in another paper in these proceedings. The assay requires less than 10 minutes, needs only a simple spectrophotometer, and has been found to be easy and reliable. The precipitation test is being developed as a qualitative assay for use in the field where laboratory equipment is unavailable. The principle by which histamine inhibits lattice formation and consequently agglutination and precipitation is shown in Figure 3.

Figure 2

Effect of Time on Diamine Oxidase Binding to Polystyrene

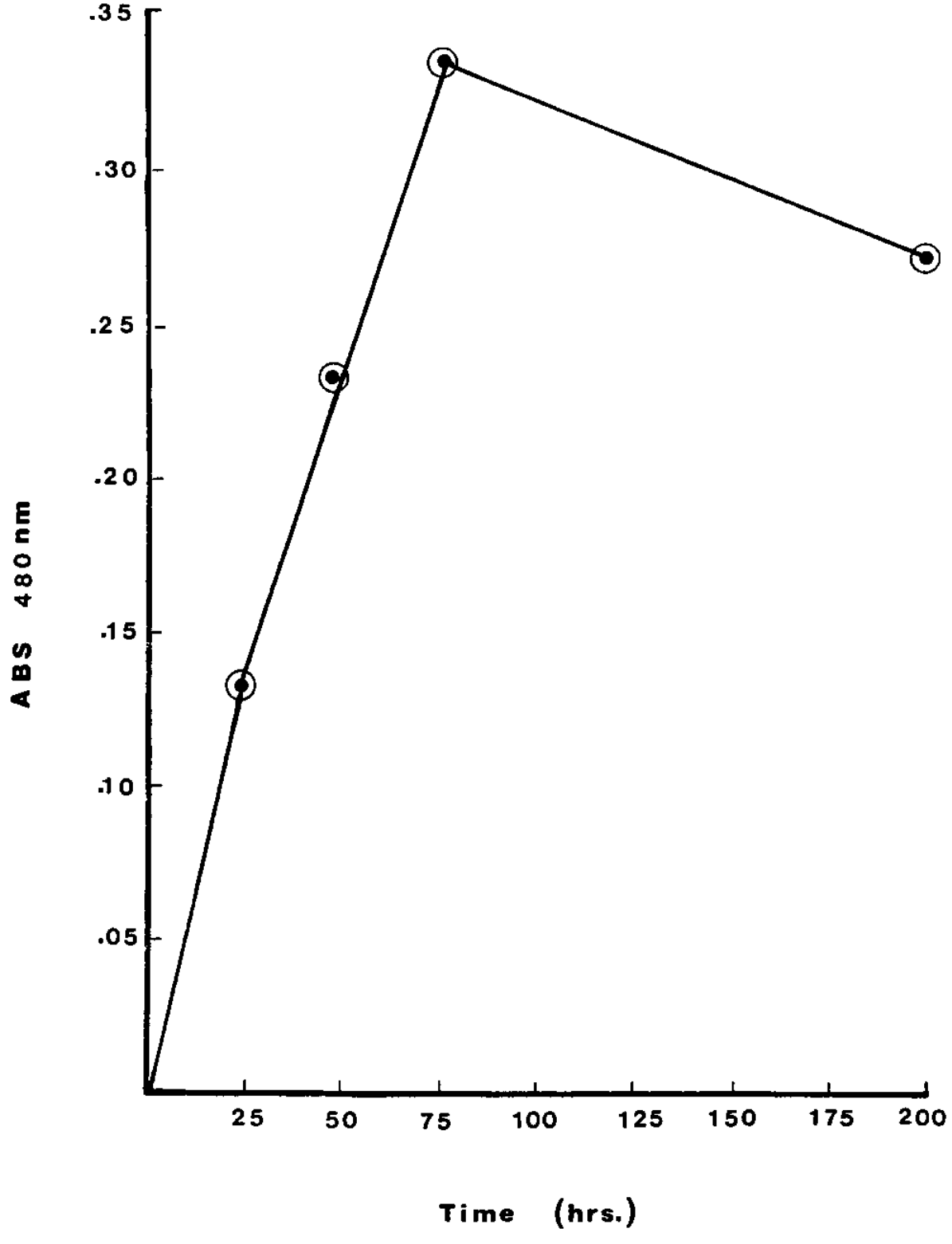
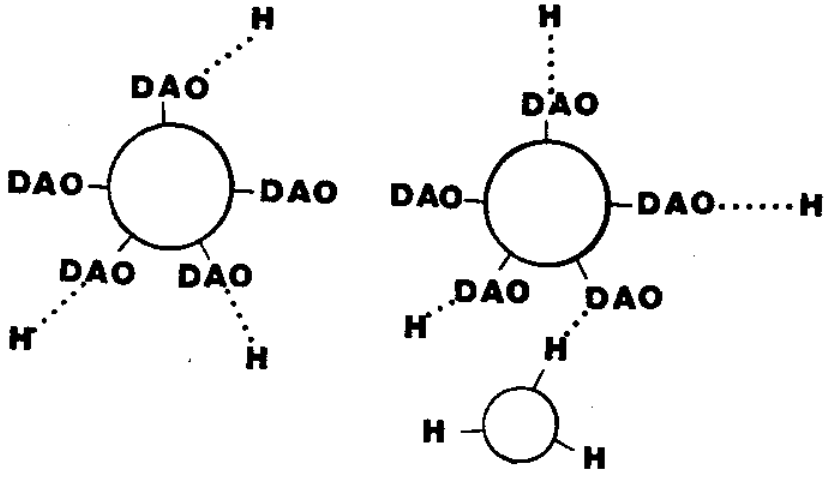


Figure 3

Inhibition of Aggregation by Free Histamine



CONCLUSION

Substitution of diamine oxidase--an enzyme with a high association constant for histamine and a slow rate of catalysis--for histamine antibody has allowed the extension of an enzyme-linked immunosorbent assay for a low molecular weight compound for which antibody is not available. This new approach has been designated Enzyme Affinity Assay (EASY).

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QUANTITATION OF HISTAMINE IN TUNA USING AN ENZYME AFFINITY ASSAY

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The Enzyme Affinity Assay is a new technique which has recently been developed in our laboratory as a means of determining the histamine concentration in tuna. Histamine is accepted as the best indicator for assessing the quality of tuna fish. The present Association of Official Analytical Chemists (AOAC) method for determination of histamine is sensitive, reproducible and specific but requires careful analytical techniques. An analyst doing only histamine analyses can do only about 30 samples a day. As a result only a small amount of the raw or processed tuna is subjected to a histamine analysis.

The Enzyme Affinity Assay is similar in principle to the Enzyme Immunoassay (EIA) introduced by B.K. van Weeman and A.H.W.M. Schuurs in 1971 except that the Enzyme Affinity Assay requires no antibody.

In the EIA an antibody is affixed to a solid support such as a polystyrene tube. Free antigen in the sample is then allowed to compete with an enzyme-antigen conjugate for the antibody binding sites on the tube. The amount of enzyme bound to the tube following washing to remove all non-bound antigen, either free or conjugated, is inversely proportional to the amount of antigen in the sample. In the Enzyme Affinity Assay the antibody is replaced by a specific binding protein, such as an enzyme. Thus there is no requirement for the ligand to be antigenic or haptenic.

The present application of this method utilizes the enzyme diamine oxidase (DAO) which specifically binds histamine, an indicator of spoilage in tuna. Histamine, conjugated to another enzyme such as horseradish peroxidase, is mixed with the histamine containing sample. This is then introduced into a tube to which DAO has been adsorbed. Histamine in the sample competes with the histamine-peroxidase conjugate for binding sites on the DAO and, following washing to remove unbound peroxidase, the amount of bound activity is an indication of the amount of histamine in the original sample.

MATERIALS AND METHODS

Buffer Preparation

The primary buffer was 0.01 M sodium phosphate (pH 6.5) with 0.1 M NaCl (Buffer A). In some cases this same buffer at pH 7.3 was used (Buffer B).

Preparation of DAO coated tubes

Various concentrations of diamine oxidase (Sigma) were prepared in deionized water, Buffer A or Buffer B. These solutions were then introduced into polystyrene test tubes (Curtin-Matheson Scientific

Evergreen Scientific) and incubated at room temperature for varying periods of time. The tubes were then washed several times with water, Buffer A, Buffer B, Buffer A with 0.1% BSA (w/v) (Sigma) or Buffer A containing 0.5% (w/v) Tween 20. Some of the tubes were then incubated with other protein solutions as coating proteins and washed again several times. Tubes were stored at room temperature or frozen until used.

Preparation of Enzyme-Histamine Conjugates

Horseradish perioxidase (Sigma) or β-galactosidase was conjugated to Histamine (Sigma) using 1-ethyl-3-(3-dimethyl-aminopropyl) carbodiimide hydrochloride (Sigma) by the method of Goodfriend (1964).

Enzyme Assay

Horseradish peroxidase was assayed using o-dianisidine or 2-2'-azino-di- (3-ethyl-benzthiazolin-6'-sulfonate) (ABTS) (Boehringer-Mannheim) as substrate; o-dianisidine (15 mg) was dissolved in 50 ml of citric acid-NaOH buffer (pH 4.0); 0.05 ml of 3% H_2O_2 was then added; 0.5-2 0 ml of substrate was added to the assay tubes and incubated at room temperature for 5-10 minutes. Following the incubation 0.5-2 0 ml of 6 M H_2SO_4 was added to stop the reaction. The absorbance was then measured at 480 nm or 466 nm in a Bausch and Lomb Spectronic 2000 or in a Turner, Model 350, spectrophotometer. The ABTS procedure was that of Standefer and Saunders (1978).

β-galactosidase activity was determined using 0-nitrophenyl-β-D-galactopyranoside (Sigma) dissolved in Buffer B containing 0.01 mM $MgCl_2$ 920 mg/ml). Absorbance readings at 410 nm were made at intervals in the Turner spectrophotometer.

Enzyme Affinity Assay

For the enzyme affinity assay various dilutions of the enzyme-histamine conjugates, with added free histamine, were introduced into the DAO tubes, incubated for varying times at room temperature and then washed several times with one of the buffers. Enzyme substrate was then added and the enzyme assay performed as described above.

RESULTS AND DISCUSSION

Determination of method of choice for preparing DAO coated tubes

Variables which were considered to determine the best method for preparing the DAO coated polystyrene tubes are shown in Table 1. Twenty-four batches of tubes using various combinations of the listed parameters were prepared. The two most important variables were the concentration of DAO used and the coating protein used. The DAO concentration is critical to the sensitivity of the assay and will be considered in more detail below.

TABLE 1. Variables Affecting DAO Tube Preparation

DAO Concentration (mg/ml)	Incubation Time	Diluent	Wash Solutions	Coating Protein
5	several days	deionized water	deionized water	BSA
3	72 hours	Buffer A	Buffer A	Hemoglobin
1.5	36 hours	Buffer B	Buffer B	Thyroglobulin
0.75	18 hours		Buffer A with 0.5% Tween 20	Trypsin*
0.01	1 hour			
0.001				
0.0001				

*The trypsin used was inactive.

Figures 1A and 1B shows comparative ratios for various coating proteins. These ratios show that the histamine-enzyme conjugate and/or the free histamine bind significantly to all coating proteins used, especially after 48 hr. incubation with the coating protein. Figure 1C shows the results of a typical assay using the trypsin coated tubes. Figure 1D shows the results obtained when five new tubes were washed five times with Buffer A containing 0.5% Tween 20 (Tween-Buffer A). The blank tube contained nothing but enzyme substrate. This indicates that after washing the tubes with Tween-Buffer A, there is almost no non-specific binding occurring.

The method of choice developed for preparation of the DAO tubes was to incubate with a DAO solution in Buffer A for varying periods of time, wash the tubes with Tween-Buffer A and either air dry them or freeze them until they were used.

Comparisons of different parameters of the enzyme affinity assay

Although tubes prepared using 0.1% BSA as a coating protein showed considerable non-specific binding, Figure 2 shows the results of assays run on these tubes. Tubes prepared with 0.75 mg/ml DAO solution were used for both assays.

Figure 3A shows the results of an assay using the ABTS substrate. This substrate has an advantage over the o-dianisidine in that the latter is carcinogenic. For this reason, the ABTS might be the substrate of choice. However, due to the longer incubation time required for ABTS, o-dianisidine was used for the majority of these assays. The DAO tubes for this assay were prepared with a DAO concentration of 10 µg/ml.

The assay shown in Figure 3B was performed in tubes prepared as part of the same batch as those used in the assay shown in 3A. This assay was performed using o-dianisidine as substrate. If the slopes of the two plots are compared, 3A has a slope approximately 1.5 times that of 3B. This might be another reason for selecting the ABTS over the o-dianisidine for use in this type of assay.

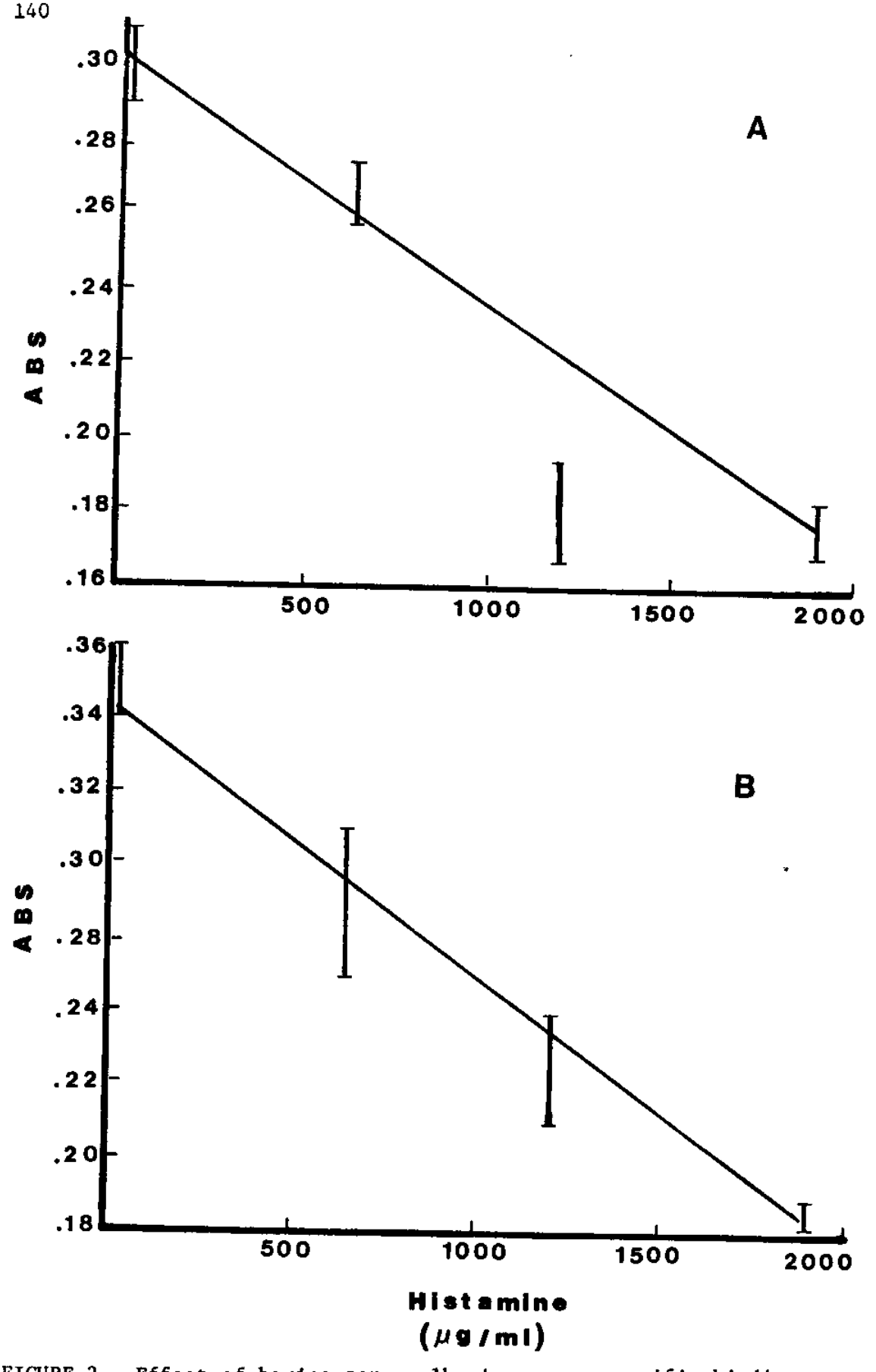


FIGURE 2. Effect of bovine serum albumin on non-specific binding.

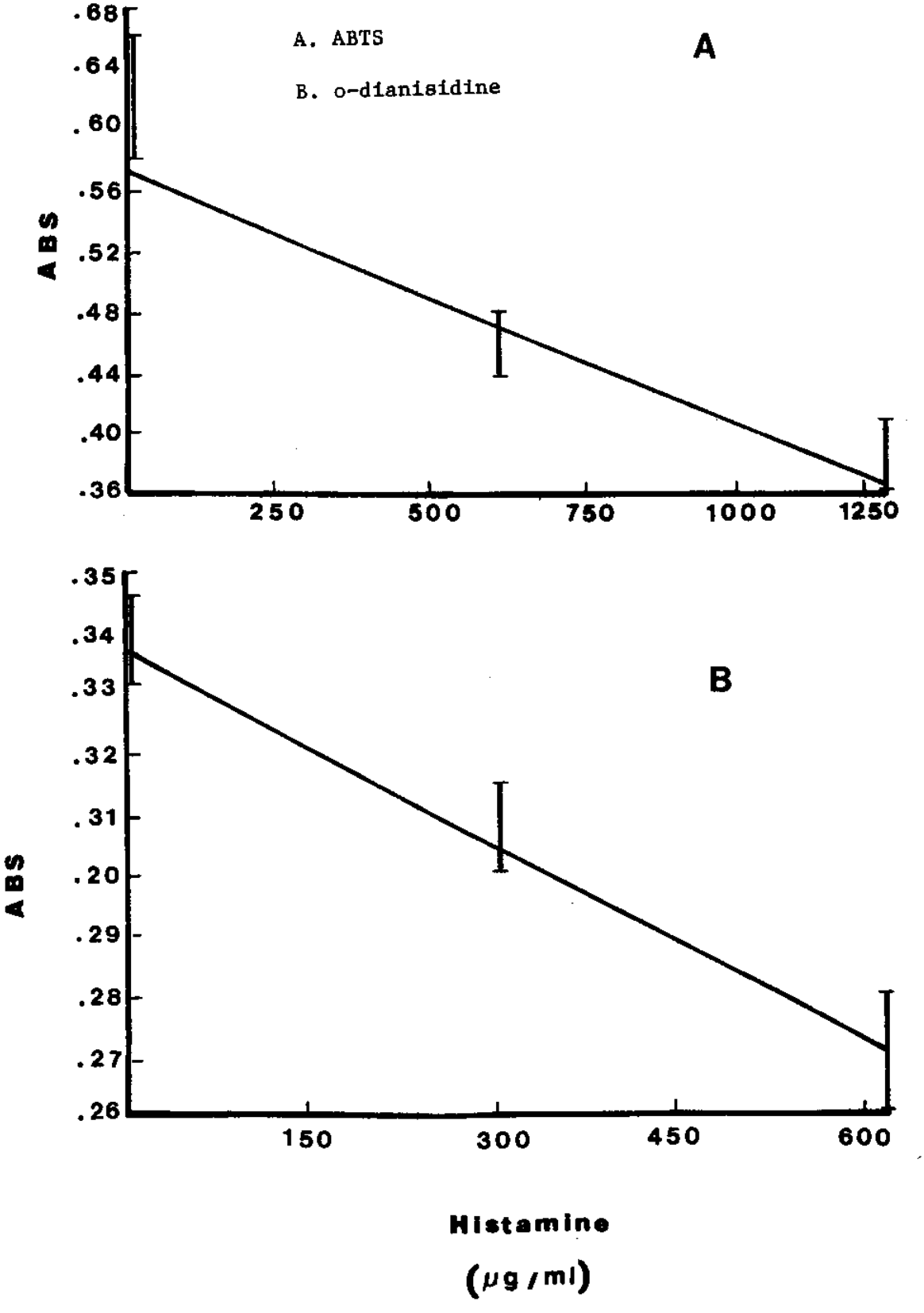
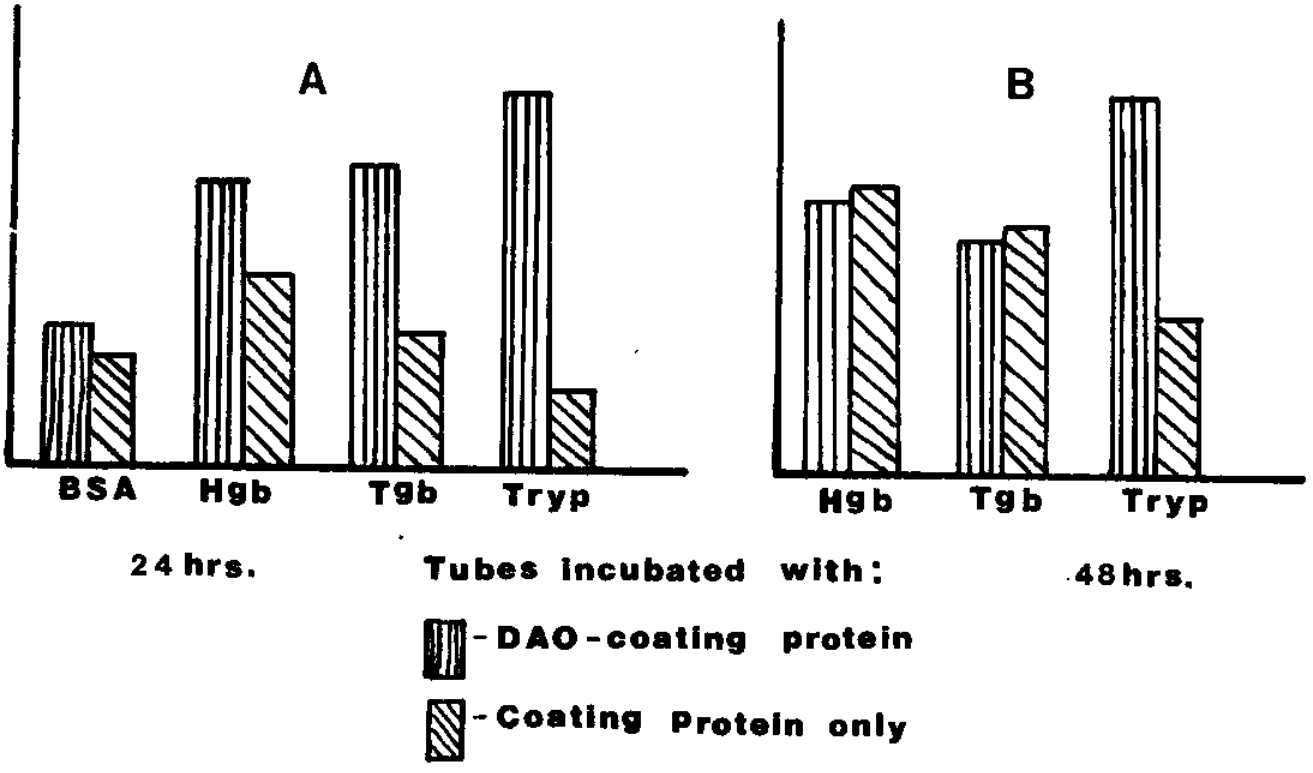


FIGURE 3. Comparison of ABTS and o-dianisidine substrates.

A. Effect of incubation at 24 hours

B. Effect of incubation at 48 hours



C. Enzyme affinity assay with trypsin coated tubes

D. Effects of detergent on non-specific binding

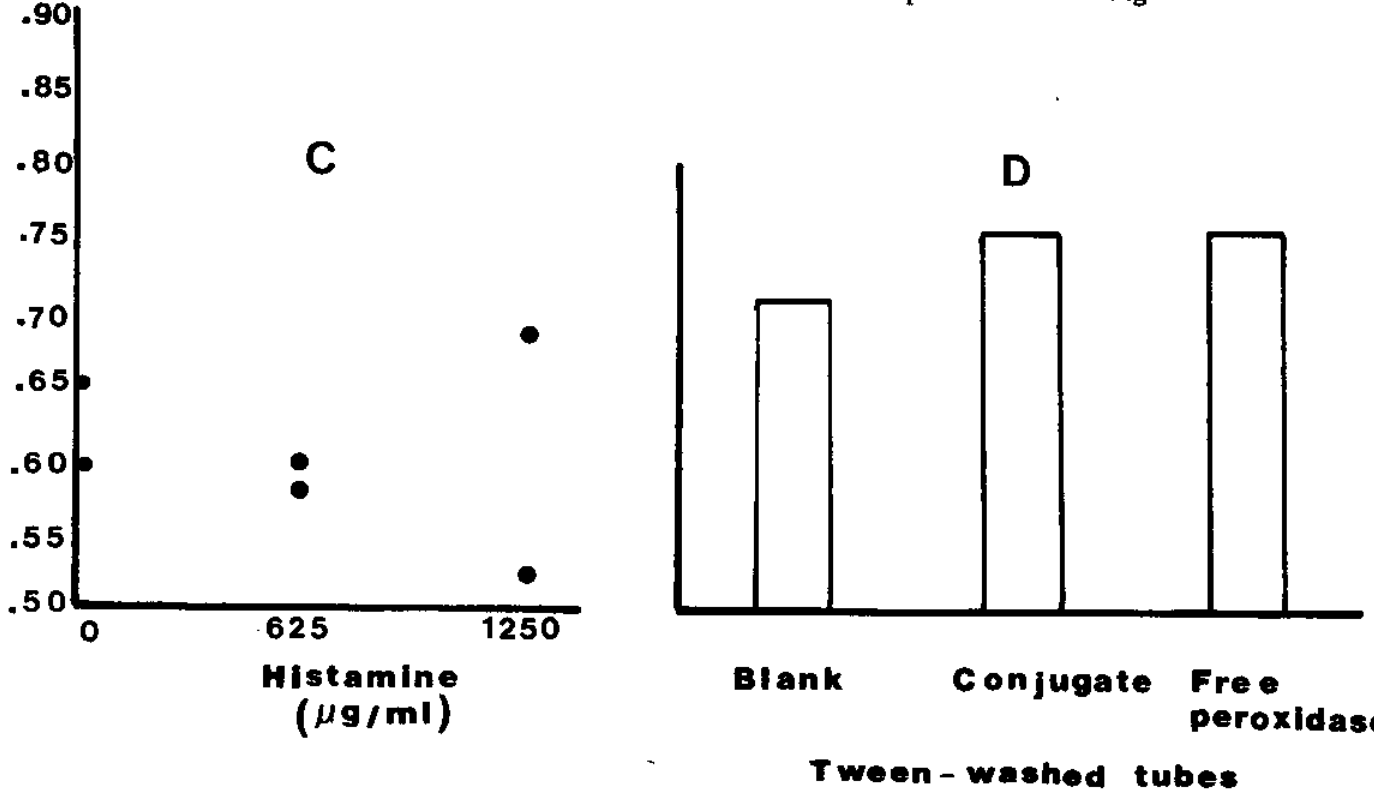


FIGURE 1. Evaluation of non-specific binding by coating proteins.

Figure 4 represents assays performed in an identical manner on tubes from two different manufacturers. The assay shown in A was performed in tubes from Curtin-Matheson and that in B in tubes from Evergreen. Both sets of tubes were incubated with 1 µg/ml DAO and treated identically throughout the procedure. The Curtin-Matheson tubes show a slightly greater slope than the Evergreen tubes. Of greater importance, however, is the fact that, in this particular assay, the Curtin-Matheson tubes show better linearity.

An illustration of the importance of balancing the conjugate concentration can be seen in Figure 5. Both assays were run on tubes prepared in the same batch. The only difference in the assays was that the conjugate used in B was more concentrated by a factor of about 1.4 than that used in assay A. It is readily apparent that, while the more concentrated conjugate gave higher absorbance values, reproducibility between tubes was much worse.

Another important point about the assay shown in Figure 5 A is that with a low DAO concentration (10 µg/ml) used to coat the tubes and the proper balance of conjugate it is possible to determine lower concentrations of histamine than has been seen in the previous assays.

Evaluation of β-galactosidase-histamine conjugate

The β-galactosidase-histamine conjugate prepared proved to be unacceptable for use in this assay. Using tubes with 1 µg/ml (the same ones used for the assay in Figure 5) the absorbance reading following a 1 hour incubation at 37°C was only 0.15.

CONCLUSIONS

The Enzyme affinity Assay appears to be an attractive method for the assay of histamine in tuna. The primary advantage of this method over the currently accepted AOAC method is that it is quick (the DAO binding step requires only 3 min. and the enzyme assay using peroxidase and O-dionisidine as substrate, requires only 3 more min.) and does not require either highly trained personnel or the use of sophisticated equipment. It is even possible that the method can be adapted in the future to a semi-quantitative test which requires no instrumentation at all and can be done "in the field" by virtually anyone.

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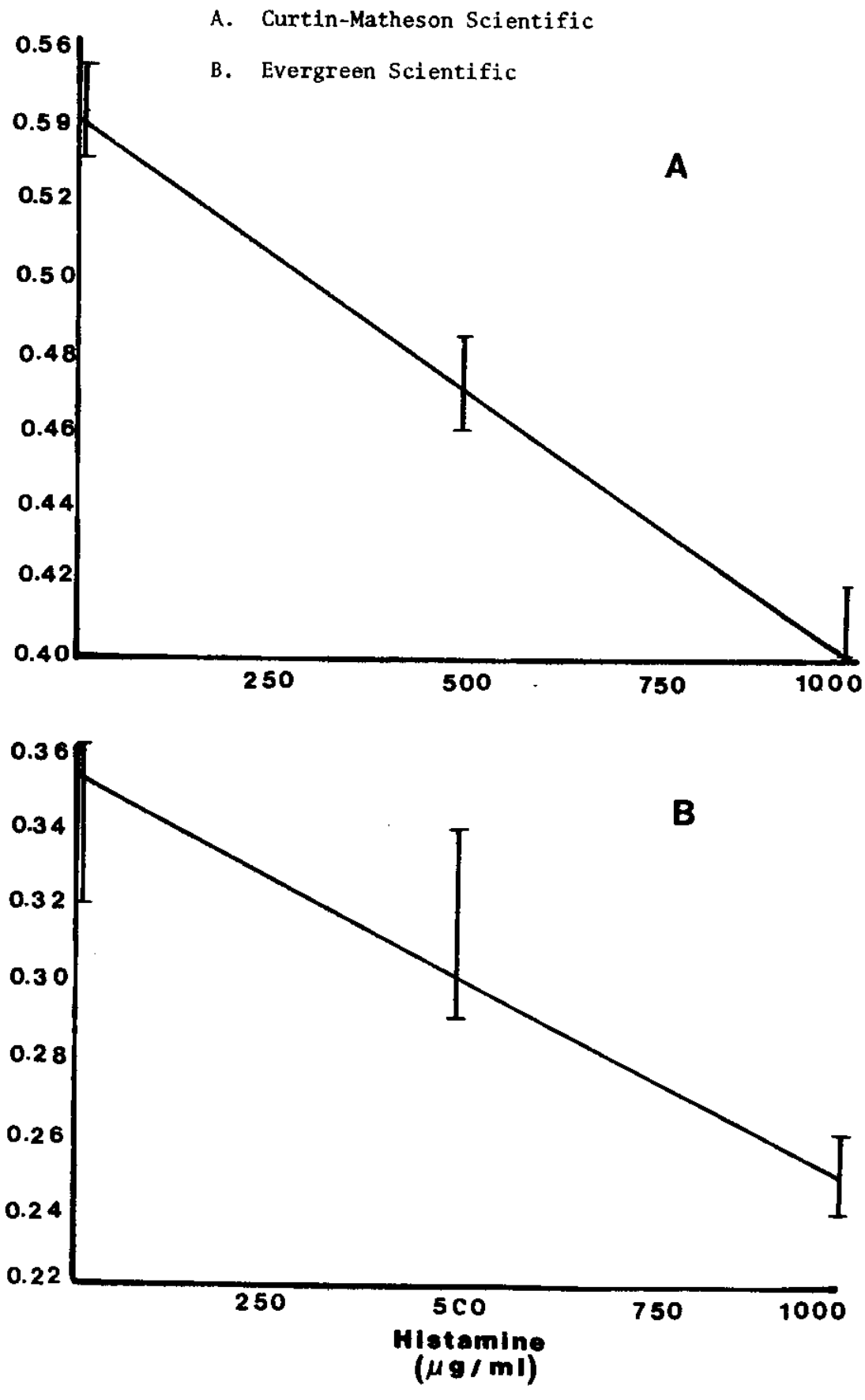

FIGURE 4. Comparison of polystyrene tubes from different manufacturers.

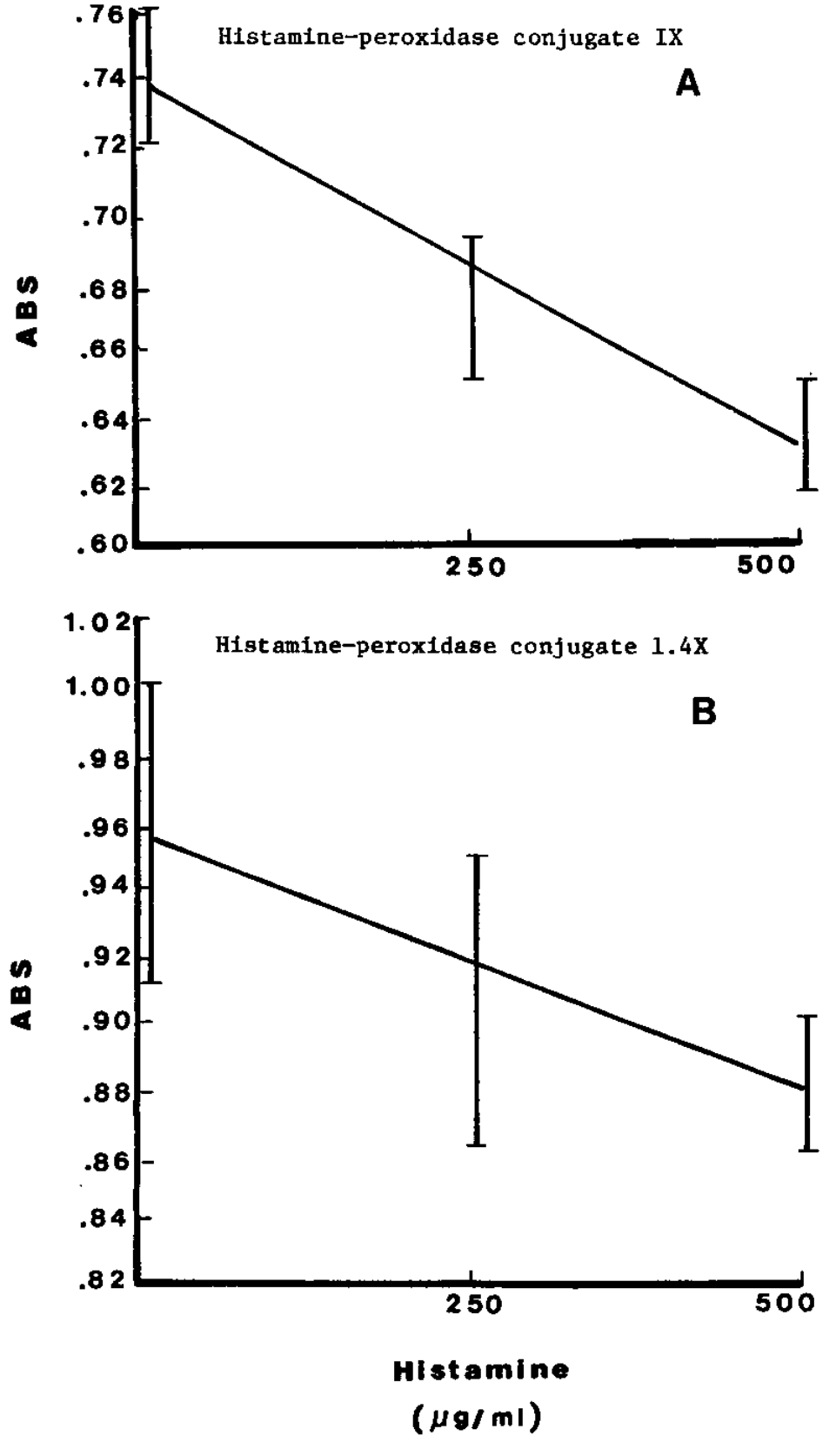

FIGURE 5. Effect of conjugate concentration on assay.

REVIEW OF WASTE MANAGEMENT REGULATIONS AFFECTING THE SOUTHERN SEAFOOD INDUSTRIES

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Waste management will continue to be a major problem facing the seafood processing industry in the 1980's (4). The current effluent guidelines for most seafood firms with direct discharge require waste treatment equivalent to 20 mesh screening and appropriate disposal of solids. EPA's concern for the level of compliance with these regulations has been demonstrated recently by letter inquiries mailed to various seafood firms throughout the southeast. The response has indicated compliance is lower than required. These inquiries have increased industry concern for waste management regulations.

Recent changes in permitting procedures will complicate efforts to comply with environmental regulations. Seafood firms must now complete a new consolidated NPDES permit. These permits require a more in-depth description of the processing operations. Changes in landfill requirements and increasing energy costs will limit solid waste treatment options.

Despite these current waste management problems, EPA is developing the second level of effluent limitation guidelines mandated for July 1, 1984. Preliminary results indicate these future guidelines may be 60 to 90 percent more restrictive. The controversial proposed technology is dissolved air flotation (DAF). EPA economic studies have indicated the DAF requirement could force closures of numerous southern seafood processing firms. Executive orders by the new Federal administration have established a presidential task force on regulatory relief and guidelines to reform the regulatory process. Various regulations, including DAF, will be reviewed with more attention to "cost-benefit" evaluations.

CURRENT SITUATION

The prevailing waste management regulations were mandated in the Federal Water Pollution Control Act Amendments of 1972 and 1977. The primary objective of these Clean Water Acts was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters". The primary administrative authority to plan and enforce these Acts was the U.S. Environmental Protection Agency (EPA). Various State Environmental Regulatory Departments were established and adopted programs were patterned by the original acts.

The original regulatory plan was to specify a series of interim guidelines or goals which would lead to zero discharge into navigable waters by 1985. These guidelines are actual specified concentrations of various pollutants which could be permitted for discharge. The pollutants discharge from seafood processing plants are conventional pollutants, as opposed to toxic pollutants. Conventional pollutants include total

suspended solids (TSS), oil and grease (O&G), biological oxygen demand (BOD), fecal coliforms, and pH. The various guidelines of concentrations per industrial source are commonly referred to with acronyms (Table 1).

TABLE 1. Schedule of interim guidelines for waste water regulations.

	Date for Compliance		
Source	July 1, 1977	July 1, 1984	1985
Direct Discharge	BPT	BCT	ZERO
Municipal Discharge	Pretreatment Standards		
New Source	New Source Performance Standards (NSPS)		

BPT - Best Practical Technology.
BCT - Best Conventional Technology.

Municipal discharge or seafood effluents discharged into public owned treatment works (POTW) must comply with pretreatment standards which assure the wastes will not overload the facility, interfere with the municipal treatment process, or pass untreated. These standards are usually specified in a sewer use ordinance. Although common complaints are voiced against the limited carrying capacity and increasing costs of municipal waste treatment, most southern seafood plants discharging to municipal facilities have experienced no pretreatment regulations which have complicated the use of municipal facilities.

New source discharges are new seafood plants being constructed such that the installation may discharge pollutants. Effluent guidelines permitted for new sources are intended to be more stringent than for existing facilities with comparable operations. This form of regulation plans to prevent installation of obsolete technology.

Southern seafood plants with direct discharge into navigable waters[1] must obtain NPDES permits (National Pollutant Dischargd Elimination System). These permits can be issued by the regional EPA office in Atlanta, Georgia, and/or by the respective state environmental regulations office which has been approved for NPDES permitting. These permits specify the daily average and maximum concentrations of conventional pollutants which can be discharged form the plant. The sampling point for measuring concentrations is "at the end of the pipe," rather than after discharge into the receiving waters. Monitoring requirements are specified in the permit.

As noted in Table 1, the current EPA effluent guidelines for seafood plants with direct discharge are "best practical technology" (BPT). The various seafood categories are not permitted to discharge effluents containing pollutants in excess of the listed concentrations (Table 2).

[1]Navigable waters does not imply navigability, but refers to all "waters of the United States".

TABLE 2. Current seafood processing effluent guidelines (BPT) in comparison with the suggested new guidelines (BCT) specified in EPA contract Report No. 68-01-3287.

Seafood Categories	Existing Guidelines (BPT)		Suggested Guidelines (BCT)**	
	TSS*	O&G*	TSS	O&G
Shrimp, Southern				
Non-breaded	110**	36		
	(38)	(12)	6.7	1.1
Breaded	280	36		
	(93)	(12)	14.6	1.5
Blue Crabs				
Conventional	2.2	.60		
	(.74)	(.20)		
Mechanized	36	13		
	(12)	(4.2)	3.5	0.8
Oysters				
Hand shucked	19	.77		
	(15)	(.70)		
Steam & Canned	270	2.3		
	190	(1.7)	13.8	1.0
Clams				
Hand shucked	59	.60		
	(18)	(.23)		
Mechanized	90	4.2		
	(15)	(.97)	1.2	.16
Menhaden†				
w/o solubles	2.6	3.2		
	(1.7)	(1.4)		
with solubles	2.3	.80		
	(1.3)	(.63)		
Catfish†				
Farm Raised	28	.60		
	(9.2)	(.20)	3.5	.35

* TSS and O&G represent Total Suspend Solids and Oil and Grease, respectively.
** All pollutants are expressed in pounds of pollutant per 1000 pounds of raw product processed. The daily maximum limit is expressed in the top figures and the daily average limit is expressed in parenthesis in the lower figures.
*** The guidelines suggested in EPA Contract Report No. 68-01-3827 are expressed in pounds of pollutants per 1000 lbs of raw product. These figures were converted from the projected performance for selected End-of-Pipe treatment technologies list in the report table 60 using model production figures from report tables 85 - 115.
† Menhaden and Catfish categories have guidelines for biological oxygen demand which are not noted in this table.

State agencies retain the authority to implement more stringent regulations, which, in most cases, assure compliance with state water quality standards. In situations which have no distinct seafood category, EPA can apply a "best engineering judgment" to set effluent guidelines in reasonable approximation of the established guidelines. For example, shrimp packaging houses in certain regions of the southeast cannot discharge settleable solids in excess of 15 ml/l as a daily average, and 25 ml/l as a daily maximum.

Thus a review of the current situation indicates southern seafood firms are attempting to comply with the existing regulations, but increasing energy costs and solid waste handling pose economic and technical problems which have not been solved. This situation must be considered when developing new regulations or the next interim of guidelines.

FUTURE SITUATION

In the near future seafood processing forms should anticipate three major changes in waste management:

1. Consolidated permitting
2. Pretreatment standards for municipal discharges
3. New effluent guidelines (BCT), the July 1, 1984 interim

Consolidated permitting became effective July 18, 1980. This was an attempt to improve the permitting process. Applicants for direct discharge permits must complete more detailed and complicated NPDES forms. The new forms (NPDES Form 2C) require:

1. Listing the latitude and longitude for each outfall to the nearest 15 seconds.

2. Preparing a line drawing showing the water flow through the facility from intake to discharge. The drawing must show water flow and balance through unit processes, production areas, sanitary flows, cooling water and stormwater runoff.

3. Listing of at least one analysis for biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), ammonia, flow, temperatures, and pH. More specific analyses may be required for certain pollutants, i.e., fecal coliforms, oil and grease, residual chlorine, etc. All suspect toxic pollutants will be analyzed.

4. Signature certification by the vice president of a corporation or a general partner or proprietor of a partnership or sole proprietorship, respectively.

Industrial sources which depend on municipal waste treatment should anticipate increasing costs for waste treatment, more pretreatment standards and potential limits on municipal services. The 1980 census report indicates the most rapid population growth is in the southeastern region of the United States. Ten of the 20 most populated cities were located in Florida. Increasing populations reflect a demand for municipal waste treatment facilities and in areas along the southeastern coasts municipal facilities are not adequate to handle the existing demands. Future demands for municipal waste treatment could force more pretreatment

standards to control waste loads contributed from industrial sources. Likewise, the costs for construction and operation of municipal facilities may depend on more support through increasing cost for industrial users. This situation is further depressed by the Federal administration's recent budget proposal which recommends substantial reductions in EPA's construction grants for public-owned treatment works. Thus seafood processing firms which have avoided waste management problems by municipal discharge should anticipate future adjustments.

Direct discharges can anticipate the next step or interim guidelines for effluent limitations due July 1, 1984. To develop these guidelines, EPA has contracted the services of two consulting firms. One firm reported recommended waste treatment technology and effluent guidelines per various seafood categories (2). The second firm reported the economic impact assessment of the recommended technology in the first report (3). These reports were strongly contested by industry opposition which felt the recommended technologies were unnecessary, ineffective, and would impose severe economic burdens. The economic impact report is being revised for resubmission in late April, 1981.

The original technical report (2) recommended effluent guidelines that are 60 to 90 percent more restrictive than the existing BPT guidelines (Table 2). The recommended waste treatment technology is listed per seafood category in Table 3. The most controversial technology was dissolved air flotation (DAF). The DAF process used minute air bubbles to attach and float oil and grease and suspended matter from the carrying liquid. The separation process can be optimized by using flocculating agents like ferric chloride, alum, lime (ph 10-10.5), anionic polymers, and acid adjustments to lower pH.

TABLE 3. Future waste treatment technology recommended in EPA Contract Report No. 68-01-3287.

Seafood Categories	Waste Treatment Technology
Shrimp, Southern--non-breaded	IP, S, DAF, SD
--breaded	IP, S, DAF, SD
Blue Crab--conventional	IP, GT, S
--mechanized	IP, GT, S, DAF
Oysters--hand shucked	IP, S
--steamed and canned	IP, S, GR, DAF, SD
Clams--hand shucked	IP, S
--mechanized	IP, S, GR, DAF, SD
Menhaden--without solubles	IP (extensive)
--with solubles	IP, B
Catfish--farm raised	IP, GT, S, AL

IP - in plant modifications
GT - grease traps
GR - grit removal
S - screening
AL - aerated lagoons
B - barging
DAF - dissolved air floration
SD - DAF with sludge dewatering, only recommended for largest processing firms

There are numerous disadvantages to the dissolved air flotation treatment of seafood processing effluents:

1. Operational mode of a DAF unit requires lengthy start-up times (1-3 hours), continuous flow during operations, and lengthy shut-down and clean-up time (1-3 hours) (5). Most seafood processing operations are not a continuous process and vary daily and seasonally.

2. Trained, experienced labor is required to operate the DAF systems (6). This unique type of labor is limited and expensive. The seasonal schedule of production would be an unattractive feature for such highly trained labor.

3. High costs for DAF equipment, chemicals, power (energy), maintenance and operations, i.e.,

Estimated Costs* (figures from EPA Contract Report 68-01-3287)

Non-Breaded Shrimp		$1,000	
Plant Size	Days/Season	Capital	O&M (annual)
10 tons/day	150	230	355
30 tons/day**	150	484	625
Breaded Shrimp		**$1,000**	
Plant Size	Days/Season	Capital	O&M (annual)
3 tons/day	150	205	293
12 tons/day	150	470	580

* Does not include cost for screening.
**Includes costs for sludge dewatering.

4. Disproportionate costs are higher on smaller size firms.

5. Land availability and costs are not considered in the original cost estimate figures. Coastal real estate is limited and expensive.

6. Sludge collected is a highly putrisensible scum (95% water) which must be disposed of in an environmentally sound manner.

7. Sludge odors can be a problem and will attract flies and rodents, which are unsanitary conditions in conflict with health and food processing regulations.

8. Sludge disposal is a major unanswered problem.

   a. Fewer landfills will accept sludge (95% water) and future environmental regulations could limit sludge disposal in landfills.

   b. The chemical additions during DAF treatment limit the use of sludge as a precursor in feeds or fertilizers.

   c. Likewise, ocean disposal, which is currently permitted for raw screened seafood solids, would be restricted for chemically treated seafood sludge.

9. Energy requirements for DAF treatment would increase energy use and processing.

The original economic impact assessment (3) prepared model economic profiles for each seafood category based on 1978 dates. Analysis of the model plants' impacts were primarily based on the determination of the model plants' net present value (NPV) both before and after expenditures for controls. The results indicated the southern shrimp industries would be the most severely impacted category (Table 4). Ths industry reviewers argue these results are very conservative, and if they were adjusted to reflect current economic conditions, the percent closures per category could exceed 50 percent. Likewise, the economic impacts on local communities and the balance in foreign trade have not been considered.

TABLE 4. Overall impact of recommended technology as determined in the economic study, EPA Contract Report No. 68-01-5858.

Seafood Categories	Percent Plant Closures (%)	Annual Production Loss ($ million)	Employment Loss (# jobs)
Shrimp, Southern--non-breaded	21	28.6	370
--breaded	32	36.3	1,590
Blue Crab--conventional	0	0.0	0
--mechanized	0	0.0	0
Oysters--hand shucked	0	0.0	0
--mechanized	0	0.0	0
Clams--hand shucked	0	0.0	0
--steamed and canned	0	0.0	0
Menhaden--without solubles	0	0.0	0
--with solubles	27	4.0	0
Catfish--farm raised	5	0.2	7

Currently, most seafood plants can comply with the BPT guidelines by employing some form of screening technology which preforms at a 20 mesh equivalent. This requirement is finer than the mesh in a typical screen door (14-15 mesh). Vibrating, rotary, and tangential screens have been used in conjunction with coarse bar screens, grit chambers and/or dry clean-up. The primary objective is to remove particulate matter or suspended solids, i.e., shells, scales, bones, etc. Recently, EPA has initiated letter inquiries to determine the level of compliance for screening effluents from southern seafood plants. The initial response has indicated compliance is lower than required, and failures to comply are more typical of the smaller firms (personal communication, EPA's Atlanta regional office, April, 1981). The inquiry is not complete and the utility of the results is questionable. These inquiries have increased industry concern for waste management regulations.

Limited compliance with screening requirements is due to the lack of benefit-incentives, costs of compliance, and no attractive options for disposal of solids. A common industry opinion is: "What comes from the sea can be returned with no harm, but should provide potential benefits." This theme has been recently reinforced by the EPA Section 74

Seafood Study which concluded "some coastal areas can assimilate or disperse large amounts of waste without serious effect." Thus industry reasons that, in some cases, compliance is an expense for the sake of treatment without benefits.

Unfortunately, the benefits of utilizing screened waste solids have not developed as anticipated. It is technologically feasible to use seafood solids to produce feeds, meals, fertilizers, chitosan, etc., but the logistics and economics of production are not reasonable. Unlike most food processing industries, the seafood industry has limited control on supply which fluctuates by season, month and week. Variations in raw materials complicate waste utilization and by-product marketing. If temporary storage is used to collect solids for by-product production, preservation is an additional expense. Temporary, unpreserved storage would violate good manufacturing practices regulated by other Federal and State agencies. Currently, by-products from seafood wastes compete unfavorably in a market with cheaper synthetics, and more consistent, higher quality products which can be produced in larger volumes. In the future, costs for producing some by-products will inevitably increase as cost for energy increases, i.e. dehydrated meals.

Most seafood firms depend on disposal for solid waste management. Public and private landfills are a popular disposal option. Associated problems are availability, disposal costs, transportation costs, and odor control. Ocean disposal is a viable alternative because untreated "fish wastes" do not require an EPA Ocean Dumping Permit (1). Despite this special exclusion, ocean dumping is not popular due to the difficulties of collection and transport of solids, so as not to attract flies and rodents and to suit variable weather conditions.

Thus, a review of the future situation indicates seafood waste management requirements could become more complicated and expensive. The consequences could be plant closures, decreased domestic production, and loss of jobs. The future regulations are presently being debated and the recent change in Federal Administration should shift the debate to favor more cost-benefit assessments to test the reasonableness of new regulations.

PREDICTIONS AND RECOMMENDATIONS

1. If production costs continue to increase, limited entry and import tariffs increase in popularity, and more stringent effluent regulations are adopted, the economic consequences could be devastating to the processing sector of the seafood industries in the Southeast.

2. Dissolved air flotation should be delayed or possibly omitted as a new seafood waste treatment technology. The tentative recommended proposal date for the new regulations (BCT) is July 1981. Changes in the federal administration and budget could delay the proposal. The original mandated date for compliance with the new regulations (BCT) is July 1, 1984. If the proposed regulations are finalized in 1982, industries will have less than two years to comply.

3. Existing regulations (BPT, screening) will be enforced. EPA compliance inquiries and potential elimination of new regulations will focus more regulatory attention on existing regulations. Due to anticipated budget cuts, EPA should focus more attention on toxic pollutants. Conventional pollutants should be ranked as a lower priority problem. Regardless of priorities, screening will most likely be enforced.

4. Industry and research efforts should be directed to determine economical and logistical methods for utilization and disposal of seafood solid wastes. New and old techniques should be investigated to consider the least cost option as well as potential benefits. Low energy production techniques to produce by-product substitutes for expensive, high energy products is advised, i.e. silages for feeds or fertilizer.

5. Seafood processing firms using municipal waste treatment should examine the potential for increasing cost for treatment and pretreatment standards. These points are often indicated in the sewer use ordinance. Alternative plans for waste treatment should be considered.

6. Industry and research efforts should examine methods for water conservation and recycling during seafood processing. Water recycling is a more difficult goal which must contend with regulatory approval to suit safe drinking water standards. Availability of fresh water is threatened in some coastal areas of the southeast. Eventually, permitting to restore water quantity could be used similar to permitting to preserve water quality.

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THE CRAWFISH INDUSTRY OF LOUISIANA: A REVIEW

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Louisiana grows and processes 90% of the nation's crawfish. Last year in Louisiana, more than 60,000 acres were devoted to raising crawfish. The pond production coupled with the wild harvest yielded approximately 40 processing facilities in the state that cook, peel and package crawfish tail meat. Demand for live crawfish and crawfish meat usually exceeds supply. Growing markets outside the state have put additional demands upon this seafood. Historically, quality has been a major problem with this industry. Unlike many other food processing industries, the cooking, peeling and packaging of crawfish does not have definite recommended guidelines or specific government regulations for the production of a consistent product. Even though the typical crawfish processor will boil live crawfish and peel them by hand, the handling methods and procedures to do these steps may, and usually do, vary greatly from processor to processor. For example, one processor may cook his crawfish in boiling water for only 2 minutes, another may cook as long as 20 minutes. One processor may wash his crawfish several times before cooking, another may not wash his crawfish at all. Obviously, the omission of a processing step or a poorly conducted processing step may result in low quality.

Over the last decade, the typical crawfish peeler has changed from the small "ma and pa" operation to the more corporate patterned facility, often processing several thousand pounds of crawfish per day.

There are two distinct species of crawfish, the red swamp crawfish and the white river crawfish. Although a mixture of both species is trapped together, each species is adapted to the environment described by its name. The red swamp crawfish is by far the most common species harvested for human consumption, making up more than 60 percent of the catch.

The meat taken from the tail is currently the only economical source of meat from crawfish. On the average, crawfish will yield about 15% blanched meat from whole live crawfish. Small and medium sized crawfish will often yield more than 20% tail meat, but large mature crawfish yield only about 8% tail meat. As crawfish mature, the head and claws become proportionally larger than the tail, accounting for this significant difference in yield. Unlike shrimp and some other shellfish, crawfish are not graded according to size.

Crawfish production is not a year round processing business. In fact, fresh meat and live crawfish are available only from late November

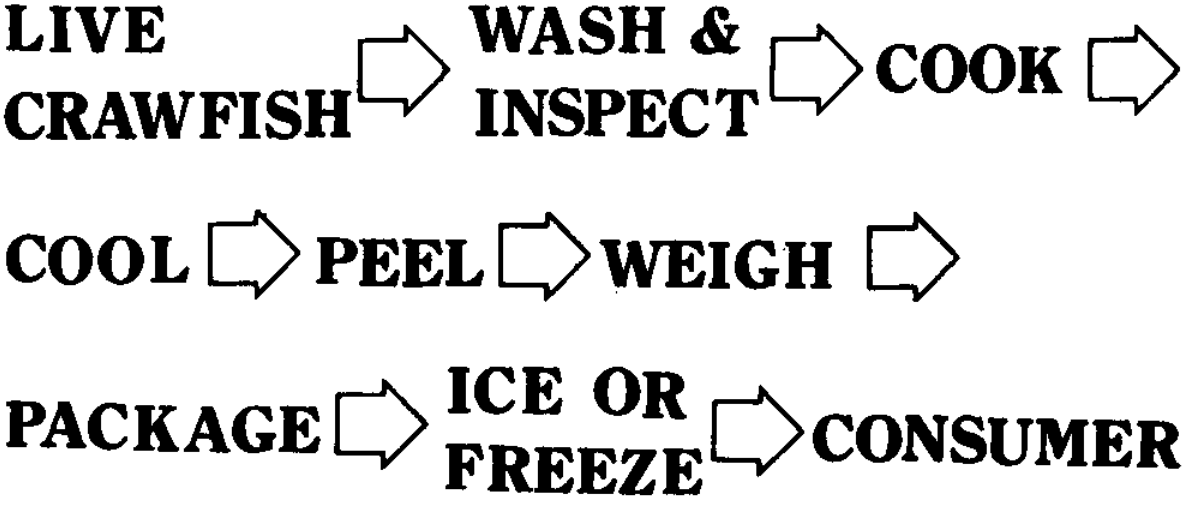
until early June during good years. March, April and May are the months when crawfish are most plentiful and are of the best quality.

During normal years, the price of crawfish varies significantly throughout the season. For example, early in the season when production is from ponds--November, December, January and February--the prices are consistently high. However, in April the prices usually plunge when the wild crop begins to be harvested. When prices drop, processing increases drastically. This year, 1981, was an exceptional year. Wild crawfish production was down throughout the season. As a result prices remained high throughout the course of the season.

Crawfish are harvested by trapping. During the season, traps are emptied and baited daily. This procedure is highly labor intensive and adds considerable cost to the overall production of crawfish.

CRAWFISH PROCESSING

Crawfish processing may be shown in schematic using the following diagram of processing steps:



Crawfish are brought to the crawfish processing plant tightly packed into onion sacks. Each sack can hold 40-50 pounds of crawfish. It is important that crawfish be maintained alive until blanching; consequently, they are stored in coolers until needed. Ideally, cooler temperature should be maintained around 40° F for live crawfish. Crawfish survive several days out of water, provided they are kept cool and have not undergone excessive stress prior to being refrigerated. It is recommended that the time live crawfish are maintained in coolers be minimized since extended storage may affect quality.

As noted in the diagram, the first processing steps are washing and inspecting the live product. A vat of water used in conjunction with water jets serves to remove mud and other debris. A conveyor belt lifts the crawfish from the water and inspectors remove dead crawfish and large pieces of extraneous matter such as bait. From the conveyor, live crawfish are placed into cooking baskets.

The cook consists of a rapid blanch, usually five minutes or less in boiling water. Over-cooked crawfish do not peel well because the meat often sticks to the shell.

Freshly cooked crawfish are usually placed on a table or in a holding bin to cool. Once cooled so that they can be safely handled, the crawfish are peeled by hand. Warm crawfish are generally easier to peel than cool or cold crawfish. For the most part, hand peeling is the norm, although mechanization is now possible and used by several plants in Louisiana. Crawfish peelers are paid according to the weight of meat peeled. A skillful worker can produce from eight to ten pounds of meat per hour. As the tail meat is removed it is placed into a colander. Periodically, the colander is emptied and the meat is weighed. Most bacterial problems associated with crawfish processing occur in the later stages of processing due to the degree of handling by workers and poor refrigeration practices.

Crawfish meat that is going to be sold fresh need only be packed into the desired package and immediately packed well on ice.

Crawfish meat that is to be frozen, however, requires more specialized handling. Upon receipt at the weighing station, the fat should be removed by washing in clean, cold water (about 40^{o} F). If the fat is not completely removed, the meat may go rancid when frozen. Washing may be accomplished on a continuous basis using a conveyor belt and spray jets of water or on a batch basis using suitable tubs or vats. Prior to packaging and freezing, the meat should be dipped into a 0.5% citric acid solution. After packaging, the meat should be frozen at a temperature of 0^{o} F or lower and maintained at that temperature.

ALLIGATOR MEAT: AN EVALUATION OF A NEW SEAFOOD

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Regulation changes within the last decade have permitted the taking of the American alligator, Alligator mississippiensis, in specified areas of South Louisiana. In 1972, it was determined by appropriate state and federal officials that sufficient numbers of alligators existed to provide a limited harvest in three southernwestern Louisiana parishes. In 1980, 12 parishes participated in the 30-day September season, taking approximately 20,000 alligators.

Initially, only skins could be introduced into commerce. In 1978, promulgation of revised regulations provided for the sale of alligator parts, including meat. Prior to this change, the meat was discarded or consumed by the trapper. With changed regulations that now permit sale of alligator parts in addition to the skin, there is growing interest in commercial marketing of the meat for human consumption. Such use will require modification in handling procedures to insure safe, wholesome meat products as well as baseline data on meat yields and nutritional characteristics. These topics were the objects of this study.

ALLIGATOR PROCESSING

Hunters normally capture alligators with baited hooks and kill them with a firearm at the site of capture. Alligator carcasses left from skinning have ordinarily been discarded as waste. New regulations by the State Food and Drug Administration require that alligator meat to be sold into intrastate commerce be prepared (including skinning) in a facility and by persons having a permit issued by the State Food and Drug Administration. Since alligators are classified as seafood, they need not be slaughtered within the confines of an approved facility, but still may be killed at the point of capture.

Twelve alligators of varying lengths and weights were captured by Louisiana Wildlife and Fisheries specialists with special handling equipment and transported live to the Louisiana State University meat processing facility in Baton Rouge. The alligators were slaughtered and processed in conformity with the Louisiana Sanitary Code. After killing, the lengths and weights were recorded. Each alligator was classified as small, medium, large or extra large. The animals were skinned, eviscerated and washed. The dressed carcasses were weighed. Other parts removed from the carcasses were also weighed separately. After chilling in a meat locker at $35^{\circ}F$ for 12 hours, the carcasses were reweighed and butchered into four primary meat cuts. The cuts were from the tail, leg, torso and jaw muscles. The tail meat cut was obtained by cutting across the base of the tail just behind the hind legs. The leg meat cuts were obtained by severing the joints where the legs attach to the body. The jaw meat cut consisted of the jaw muscles. The remaining meat from the back and ribs was categorized as the torso meat cut. The only boneless cut was the jaw meat cut.

A proximal analysis (protein, fat, moisture and ash) of the various cuts of meats was determined. Analyses were run on only those portions of each cut that could be expected to be consumed. For example, excess fat was trimmed since alligator fat may impart a strong disagreeable flavor to the meat.

RESULTS AND CONCLUSION

Results from this study provide basic data to processors and other individuals considering marketing alligator meat in Louisiana. Tables 1 and 2 are basic yield data obtained in the study.

An interesting comparison was noted between the value of the skin and the value of the meat when both are considered on a weight basis. (The skin is normally sold according to length and not weight or area.) Last year this value was about $1 per inch. On a weight basis, the small alligator skins from the study were worth $19.82 per pound, the medium alligator skins were worth $9.81 per pound, the large alligator skins were worth $7.28 per pound and the extra large alligator skins were worth $3.47 per pound. As the size of the alligator increased, the value of the skin on a weight basis decreased. Consequently, as alligator size increased, the value of skin on a weight basis approached the value of the meat on a weight basis, assuming that the value of meat is constant, regardless of alligator size. Since the dressed weight is roughly 60 percent of the total live weight and the skin is roughly 15 percent, the value of the meat may be considerably higher than the skin on larger alligators.

The appearance of the meat cuts varied. For example, meat from the tail cut was white to light pink. Internal bands of hard, white fat--that appear circular in cross section--run lengthwise near the tail bone. Meat from the torso cut is similar to meat from the tail cut, except that it does not have the fat bands. The jaw meat is also white to light pink with no fat deposits. The leg meat, however, is darker color. Some small fat deposits were observed in the leg meat as well as a substantial amount of connective tissue and tendon.

Table 3 is the basic proximal analysis of the meat. The nutritional composition data compares favorably with other more traditional meats. While the fat content of the alligator meat ranges from 1.0 to 1.5 percent, the fat content of a choice grade beef rump roast is about 25.0 percent; for pork loin it is about 20.0 percent; for chicken (fryer, light meat without skin) it is 6.0 percent. The protein content of alligator meat ranges from 21.1 to 22.3 percent as compared to 17.0 percent of a choice grade rump roast; 13.0 percent for a pork loin; and 32.0 percent for chicken (fryers, light meat without skin). The moisture content of 73.0 to 76.8 percent is higher than other traditional meats. A choice rump roast has a moisture content of 57.0 percent; a pork loin, 57.0 percent; and chicken (fryer, light meat without skin), 60.0 percent.

TABLE 1. Alligator Yield Data

Size	Length (ins)	Live wt. (lbs)	Dressed wt. head off (lbs)	Dressed wt. head off @ 35°F after 12 hrs	Skin wt. (lbs)	Waste wt. head, viscera and feet (lbs)	Tail meat cut (lbs)	Leg meat cut (lbs)	Torso meat cut (lbs)	Jaw meat cut (lbs)
Small	56.5	18.1	11.5	11.0	2.9	4.1	3.8	1.5	4.9	0.3
Medium	77.5	49.4	30.5	30.4	7.9	11.1	10.2	3.9	13.7	0.9
Large	88.8	83.6	52.4	50.4	12.2	19.0	17.2	6.2	24.6	1.4
Extra Large	110.0	262.0	162.0	159.0	34.8	59.7	48.6	20.0	82.9	8.2

TABLE 2. Percentage Yield on a Live Weight Basis

Size	Dressed wt. head off %	Waste - head, viscera, feet and skin %	Tail meat cut %	Leg meat cut %	Torso meat cut %	Jaw meat cut %
Small	63.3	38.2	21.1	8.3	27.2	1.5
Medium	61.7	38.6	20.7	7.8	27.7	1.8
Large	62.6	37.3	20.6	7.4	29.4	1.7
Extra Large	61.8	36.0	18.5	7.6	31.6	3.1

TABLE 3. Composition of Alligator Meat

Cut of Meat	Crude Protein	Crude Fat	Moisture	Ash
Tail	21.3	1.5	76.5	1.3
Torso	21.1	1.2	73.0	1.3
Jaw	22.3	1.2	75.9	1.3
Leg	21.1	1.0	76.8	1.3

Analysis performed by LSU Feed and Fertilizer Laboratory

THE BACTERIOLOGICAL QUALITY AND SAFETY OF PASTEURIZED LANGOSTINO TAILS

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INTRODUCTION

Langostinos (Pleuroncodes planipes and/or monodon), while actually crabs, are harvested and eaten like shrimp. These crustaceans are currently being trawled off the coasts of Chile, Peru and Nicaragua. Huss and Asenjo (1976) reported catches off the Chilean coast at depths of 100-400 m, averaging one ton an hour with yields up to 13%.

MATERIALS AND METHODS

In 1978, pilot plant operations were started in Nicaragua to evaluate the feasibility of establishing a Langostino fisheries. This plant implemented a process that was successfully being used in Chile. The basic process involved the following steps:

1. Raw langostinos delivered whole, on ice.
2. Whole product cooked (blanched) by immersion in hot salt solution (near boiling) for 2 minutes.
3. Hand peeled.
4. Washed in ice water.
5. Packed in 6-oz. packages for pasteurization. Packed in 5-pound blocks for freezing, and/or placed on trays for IQF (individual quick freezing).
6. Pasteurized by immersion of the 6-oz. vacuum packaged product in 190°F water for 2 minutes and subsequent chilling in an ice slush before freezing.

RESULTS AND DISCUSSION

The pilot plant was producing an acceptable product that met the FDA guidelines for frozen-cooked langostinos (Table 1). Due to this successful operation, production was expanded to a larger operation. This expanded operation was accompanied with an increased Staphylococcus contamination in the final product (Table 2, initial process). Assistance from Texas A&M University was requested to alleviate the problem of high staphylococci counts. After on-site inspection, the reasons for the staphylococci counts were thought to be: (1) an inability to adequately control the cooking temperature, (2) a lack of personal hygiene, or (3) a combination of 1 and 2.

To produce a product that would once again be within the FDA guidelines, a modified process was developed. This process is presented in Fig. 1. It differed from the initial process by removing the tails and soaking them in a 5% PO_4 solution prior to the blanch and pasteurizing for 3 minutes at

190°F. This time and temperature produced an internal temperature in the langostino tails of 83°C for 1 minute. The newly developed process produced counts as presented in Table 2.

TABLE 1. Food and Drug Administration Administrative Guideline 7408.10 Limits for Frozen-Cooked Langostinos

1.	Coliform < 20/g (MPN) in 20% of subsamples
2.	E. coli < 3.6/g (MPN) in 20% of subsamples
3.	Staph < 3.6/g (MPN) in 20% of subsamples
4.	APC (at 35°C) < 10^5/g for all subsamples

TABLE 2. Bacteriological Data on Nicaraguan Langostinos Before and After Pasteurization

	Initial Process		Developed Process
	Unpasteurized	Pasteurized	Pasteurized
APC/g	1.3×10^5	$1.2 - 1.5 \times 10^4$	$<10^3 - 1.2 \times 10^4$
Coliforms MPN/g	9.1	<1	<1
E. coli MPN/g	<1	<1	<1
coagulase-positive staphylococci MPN/g	>1100	210-290	0-23

In 1979, the State of Florida placed in excess of 280,000 lbs. of langostino meat on a "STOP Sale". The product was subsequently seized by the FDA for adulteration under Administrative Guideline 7408.10. After frozen langostino meat had been inspected by the FDA and Florida, the owners requested a third opinion, and we were asked to sample the lots of langostino. We found (1) not all of the meat was packaged as "frozen-cooked"--some of the lots contained 5-lb. raw boxes; (2) some of the samples packed as cooked reflected high counts, similar to those counts of raw langostino; and (3) some of the samples were acceptable under the FDA Guideline.

As a result of these findings, we decided it was necessary to develop a method of determining to what temperature the product had been cooked. This was done by modifying a method used in the smoked ham industry. The technique measures the turbidity of the thaw drip when heated to different temperatures and relates it directly to the temperature at which the meat was previously cooked. Figure 2 shows typical curves of a raw lot and a sample from that lot after pasteurization to an internal temperature of 83°C for 1 minute. Figure 3 presents curves of six lots, of which only one appears to have reached the desired pasteurization time and temperature. With this method of determining degree of pasteurization, it was discovered

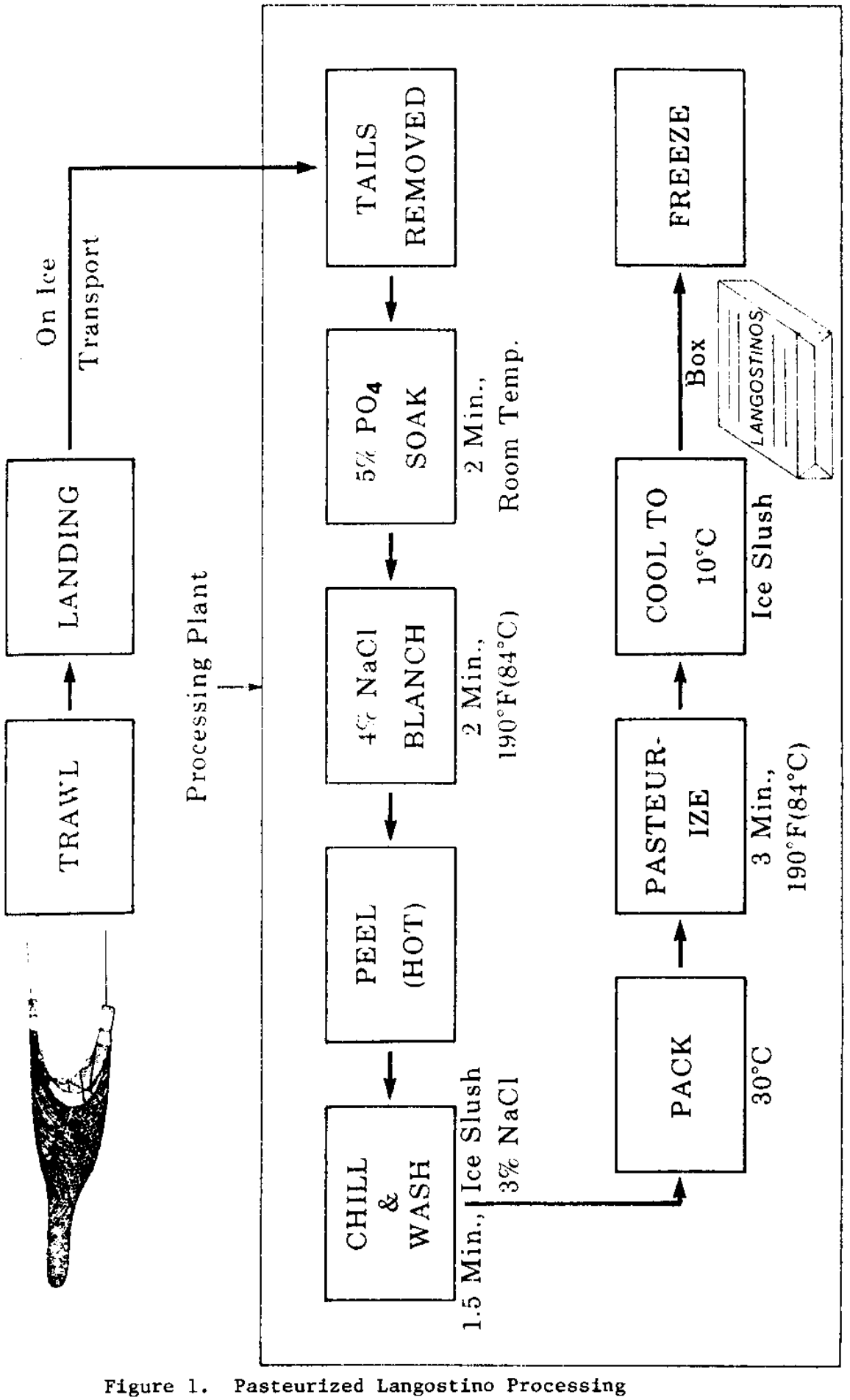

Figure 1. Pasteurized Langostino Processing

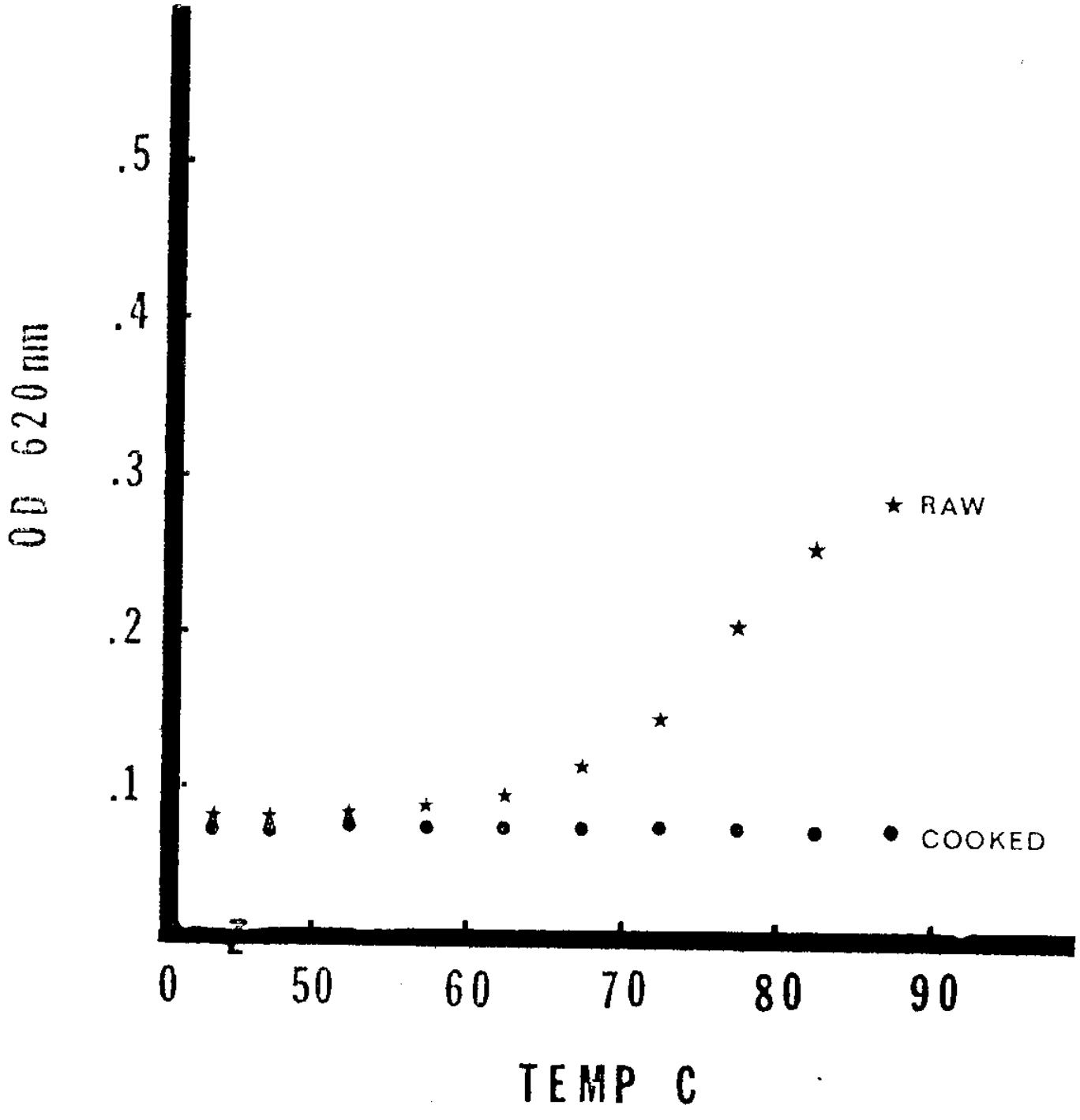

FIGURE 2. Denaturation curves for langostino thaw drip (lot 25355 raw) before and after pasteurization (85°C).

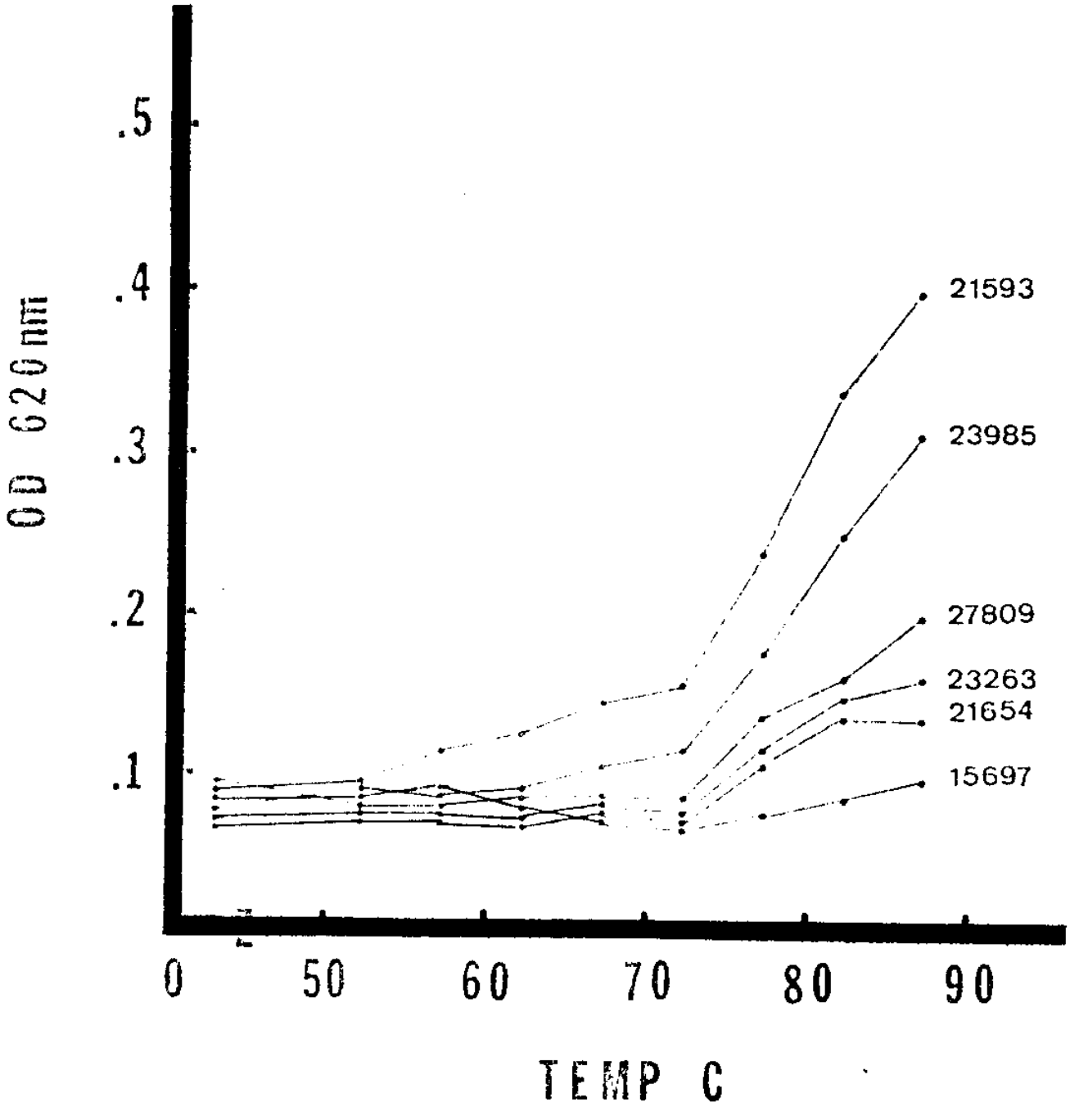

FIGURE 3. Denaturation curves from six lots of langostinos labled pasteurized.

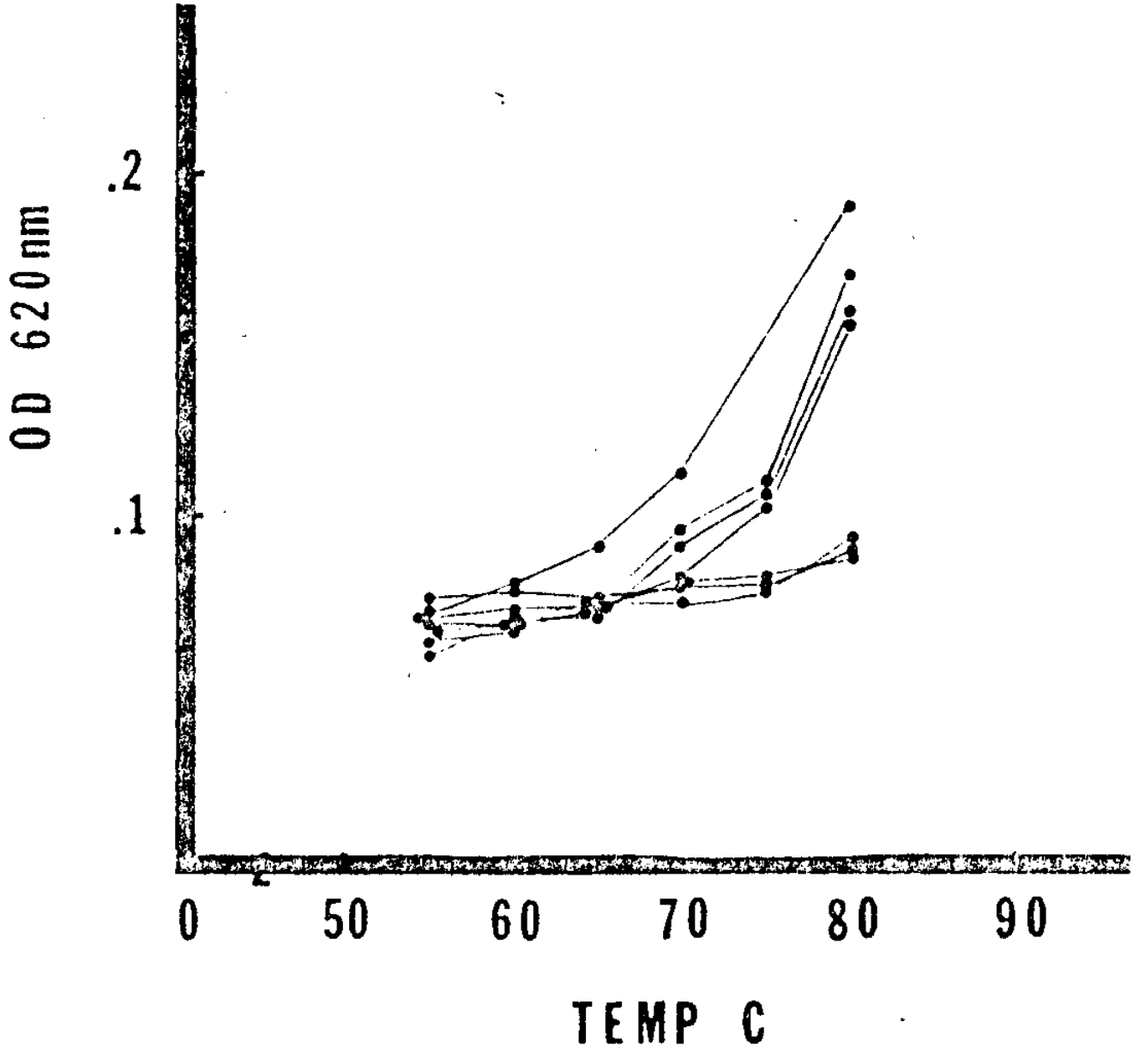

FIGURE 4. Denaturation curves on seven sub-samples of langostinos from lot 23985.

that not all lots were homogeneous. Figure 4 illustrates seven denaturization curves from a typical stratified lot. This stratification within lot appeared to be caused by the lots being transportation lots and not production lots.

CONCLUSION

From the analysis of this data we proposed new bacteriological standards (Table 3). The FDA adopted the raw standards but decided to continue to use the Administrative Guideline 7408.10 (Table 1) for cooked langostinos. Is should be noted that the adopted raw standards use the method of the International Commission on Microbiological Specification for Food for establishing bacteriological standards. This is a departure from the earlier standards of "all or none".

TABLE 3. Proposed Bacteriological Standards for Raw and Pasteurized Langostino Meat

Product Test	No. Samples (m)	Samples Accepted Between m & M (c)	m	M
Raw (blanched) APC (25°C)	5	3	10^6	10^7
STAPH	5	3	100	200
Pasteurized (80°) APC (35°C)	5	1	10^5	10^6
STAPH	5	1	100	200

The final disposition of the frozen langostino meat has not been decided. The recommendations presented in Table 4 have been presented to the FDA.

TABLE 4. Recommendations for lots of frozen-cooked langostinos

Recommendations	No. of lots	Wt. (lb)
Resample	6	64,686
Reprocess	1	16,956
Release	7	99,730
Not fit for human consumption	14	100,404

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IMPROVEMENT OF SEAFOOD QUALITY

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INTRODUCTION

Very few seafood plants have laboratory capabilities in which to monitor the microbiological quality of their products. When microbiological problems occur, plant managers are often not aware of them until their product is inspected by federal and state regulatory agencies. Moreover, the managers of the plants often lack the training necessary to identify and correct potential microbiological problems. This report is a case study of how serious microbiological problems were identified and corrected in one such plant. While this report concerns only one plant, similar stiuations are known to exist in other seafood processing plants along the Gulf Coast.

The owners of this particular plant had been processing crabs for a number of years. They started with a small processing plant, but in the late Seventies expanded their operation by building a new, much larger facility. Unfortunately, the volume of crabs processed quickly surpassed the plant's capacity. The owners were conscientious and wanted to produce a good product, but they lacked the knowledge and the time necessary to identify and correct sanitation problems. The management was primarily concerned with sales and much of their time was spent on the telephone and with accounting functions. The day-to-day operation of the plant was left largely to the plant foreman, whose main qualification was that he spoke both English and the language of the workers. The employees were predominately refugees who spoke little English.

The plant operated with two shifts. The day shift packed, weighed and packaged the crabmeat. The second shift was responsible for cooking, debacking and washing the crabs. The owners made an effort to supervise the day shift, but no effort was made to supervise the second shift. The workers on the second shift often took advantage of this lack of supervision to use the plant facilities to clean fish for personal use.

The plant owners were not aware that a sanitation problem existed until the United States Food and Drug Administration conducted an inspection. This inspection revealed that the crabmeat leaving the plant had extremely high aerobic plate counts (APC) and fecal coliform levels. Concern over this inspection prompted owners to contact the Seafood Extension Group at Louisiana State University, who in turn enlisted the help of the Food Science Department.

RESULTS AND DISCUSSION

The basic problem areas identified were the lack of (a) employee

awareness, (b) employee supervision, (c) communication between management and employees, and (d) laboratory capabilities.

To increase employee awarness of sanitation, the Seafood Extension Group prepared a slide/cassette presentation on sanitation in the native language of the workers. The slides carefully documented the correct way of handling crabmeat. It was later recommended that the owners hire a plant manager to oversee the workers and to enforce good sanitary practices. This served to increase employee supervision and communication between the owners and the workers. Also, it was suggested that a microbiology laboratory be set up to monitor the microbiological quality of the crabmeat. A Ph.D. student from the Food Science Department was hired to start this program.

In order to assess the extent of the microbiological problems, representative samples of the crabmeat offered for sale were analyzed in the Food Science Department. Microbiological analyses included testing for aerobic plate counts (APC), total coliforms, fecal coliforms and Staphylococcus aureus. All analyses were done by the methods of USFDA (1) and all media were Difco.

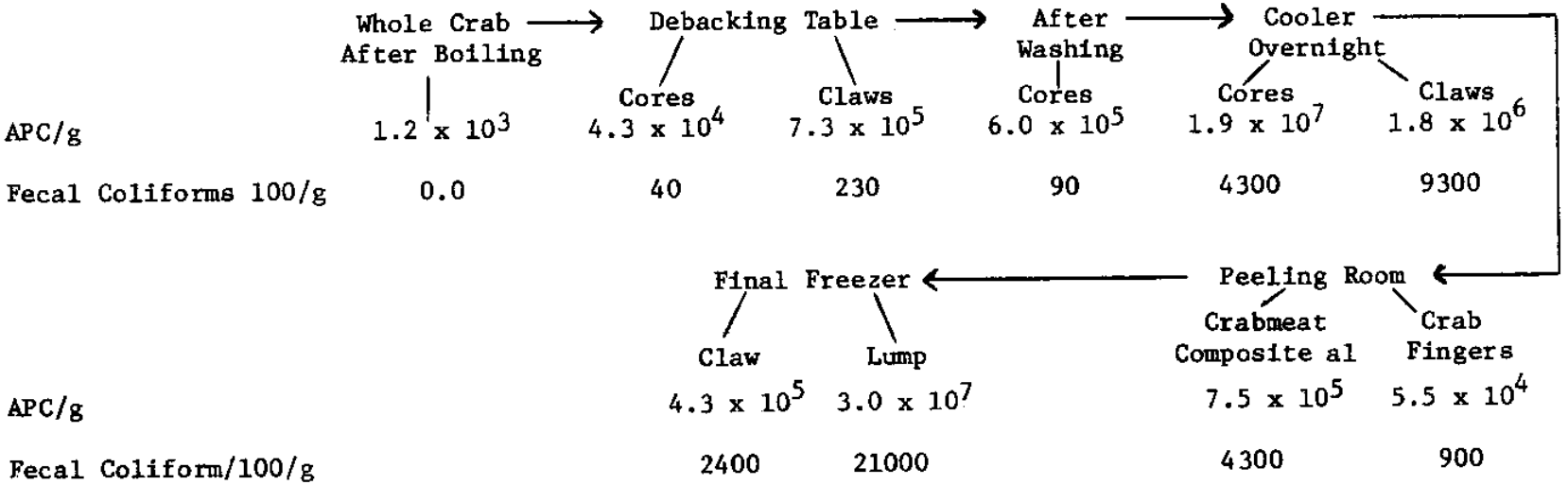
The FDA recommends that crabmeat have an APC of $\leq$ 100,000/g and a fecal coliform count of $\leq$ 50/100 g. None of the samples tested were within these recommended limits (Table 1). Line samples and careful observation were used to identify critical control points in the plant (Fig. 1). It might be noted that the crab bodies were grossly contaminated before entering the picking room. The boiled crabs had an APC of 1000/g and were free of fecal coliforms. However, fecal coliforms were added during the debakcing and washing steps (Fig. 1). The unsupervised second shift admitted to cleaning fish on the debacking tables and they did not sanitize the tables afterwards. In addition, the workers were using cloth gloves for debacking the crabs. This practice added large numbers of bacteria, including fecal coliforms, to the cooked crabs. After the crabs were debacked they were washed mechanically to remove the fat and intestinal material. Unfortunately, the washers often added to the microbial load of the crabs. This was due to the adherence of crabmeat to the frame and the presence of a protein film on the interior walls.

TABLE 1. Microbiological Quality of the Crabmeat Leaving the Plant Prior to Quality Control Program

	Aerobic plate count/g	Total coliforms/100g	Fecal coliforms/100g	Staphylococcus aureus/g
White Meat	3.2×10^6	2-8000	15000	5
Claw	1.0×10^6	2-2000	7600	125
Crab Fingers	5.5×10^6	4300	4300	50

Log average of 2 samples.

After washing, the crabs were placed into baskets and stacked into the cooler. The baskets were not being sanitized before putting the washed



[a]1-A small amount of crabmeat was taken from several pickers and combined to make one sample.

FIGURE 1. Microbiological Analyses of Crab Processing Operation Before Corrective Measures Were Initiated.

crabs into them and visual inspection revealed pieces of crabmeat and fish scales adhering to the sides of the baskets. The new plant manager quickly cleared up these problems. Plastic gloves were substituted for the cloth debacking gloves and a chlorine dipping solution was provided. The plant owners provided platforms for the baskets and the washer was thoroughly cleaned.

The cooler proved to be the main contributor to the microbiological problem. After being washed in hot water, the baskets of hot moist crabs were stacked in the cooler. The hot moist aerosol from the crabs caused the evaporators to ice up, thus restricting the air flow in the cooler. Often 18-20 h would pass before the defrost cycle cut in to thaw the evaporators. During the interim, it was not unusual to see cooler temperatures above 50°F. The water from the crabs would percolate through the crabs and pick-up water soluble nutrients, thus making an excellent bacteriological medium. When the crab bodies left the cooler the next morning, the APC exceeded 1×10^7g (Fig. 1). This situation was corrected by adding four defrost cycles and by placing shelves in the cooler. After adding the defrost cycles, the cooler temperature was maintained at approximately 32°F. This reduced the APC of the crab bodies leaving the cooler to 1.2×10^5. The fecal coliform counts were reduced from 4300 to 36/100g. We have further suggested that the crabs be cooled in the same baskets thay they are boiled in and that the debacking and washing steps be done just before picking.

The workers in the picking room were not observing good sanitation practices. The crabmeat was being picked into unsanitized metal bowls and the the workers were not dipping their hands in the sanitizer provided. The workers would pick up to 8 lb of crabmeat before weighing the bowl; this allowed the picked crabmeat to set at room temperature for several hours. In addition, the workers in the weighing room accepted the crabmeat to the nearest pound and returned the excess to the pickers. Thus, that portion might remain in the bowl all day. Finally, the picked crabmeat was being placed in plastic containers which had not been sanitized. These problems were easily solved by closely supervising the workers and requiring them to abide by good sanitary practices. The bowls are now being sanitized after each weighing and each worker is required to empty the bowl every 60-90 min.

The ice proved to be another source of microorganisms. At first it was believed that the water was contaminated, but we later discovered that the unsupervised second shift workers were storing fish and other foods in the ice.

Another unsanitary aspect of the plant was its circulating waste disposal trough. The water circulating through this trough would become saturated with proteins from the crab waste. The circulating motion would cause the solution to foam which would, at times, actually reach the top of the picking tables and contaminate the crabmeat. We recommended that the plant no longer use this system.

After corrective measures were initiated, the fecal coliform counts were reduced to acceptable levels (Fig. 2). The microbiology laboratory in the plant is operational and the crabmeat is being monitored on a daily basis. This laboratory was relatively inexpensive to set up; it

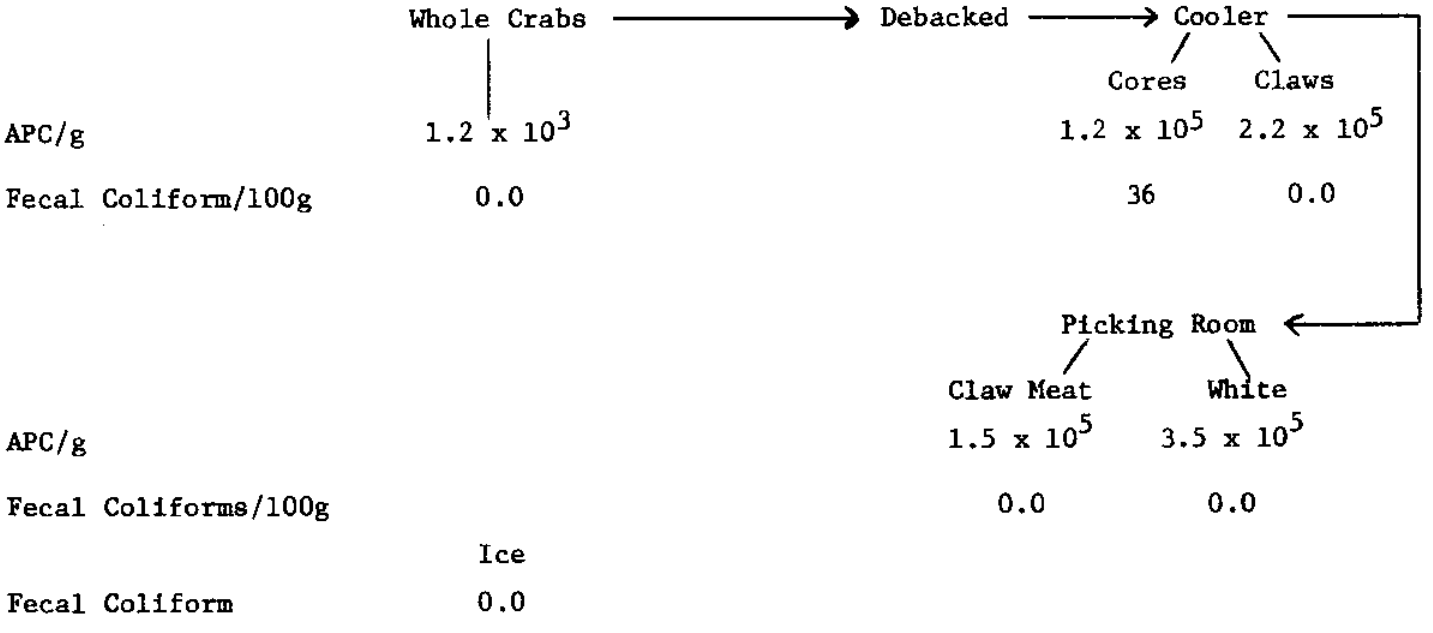


FIGURE 2. Microbiological Analyses of the Crab Processing Operation After Corrective Measures Were Initiated.

only cost about $2,000 to start. The laboratory facilities give the new plant manager feedback on the effectiveness of his corrective measures. The microbiological quality of the crabmeat has been improving steadily. At the time of this writing, most of the crabmeat samples were free of fecal coliforms and the APC levels have been decreasing (Fig. 2).

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OPTIMIZATION OF DRYING CONDITIONS FOR STOCKFISH PRODUCED FROM UNDERUTILIZED FISH: APPLICATION OF EXPLOSION PUFFING ON DEHYDRATION OF FISH

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INTRODUCTION

Among developing nations in the world today, dried fish products still possess the largest volume on the processed seafood market. They can be produced with the natural drying method using simple facilities. Their finished forms are very stable even without refrigeration. They can be packaged, stored, and shipped economically. All these are reasons for their long-lasting presence, especially in those less developed areas of the world such as African nations and China. Nigeria, for example, has been importing large quantities of high grade stockfish not available locally from all over the world in the last few decades. Although there is potential for us to fill this market, we have to compete with other stockfish producing nations. The trade can only be feasible when the production cost is kept relatively economical and the raw material used for the product is regarded as popular in their regions yet underutilized here in the United States. With the vast amount of knowledge accumulated in the past few decades on dry fish production, now should be the time to review these methods and come up with the most efficient technology for a specific dried seafood product. The possibility of using new species for producing traditional products should be investigated in regard to their acceptability by consumers and the market potential. Opportunities for modified product forms and chemical treated samples should also be tested because they represent improvement in production efficiency and product stability.

BACKGROUND

Raw Materials for Stockfish

Traditionally, the term "stockfish" has reference to unsalted, air dried fish products from any kind of fish. More recently, the most valuable stockfish products only refer to those made from cod and its family. However, dry fish products of many kinds and in various forms are said to be readily available on the dry fish market today. In the age of declining production of stockfish produced from cod and related species, other potential raw materials should be examined; they may include many locally underutilized fish such as bonito, jacks, mullet, whiting, black drum, croaker, lizardfish, tigerfish, sharks, rays, etc.

Quality Requirement

With a moisture content of less than 15%, stockfish is very stable even at room temperature. Thus, the product freshness, which is related to the quality of the raw material and the efficiency of the drying method, may not be determined by the microbial count. Rather, the presence of trimethylamine (TMA) and the nucleotide composition (K-value) may be the better indices of product freshness. The former is a by-product due to the microbial action and the latter relates to the degree of nucleotide degradation due to autolysis. The intrinsic chemical reactions due to autolysis may be desirable because they may contribute to the typical dry fish flavor. Protein solubility is another useful property which relates to the protein quality changes due to heat treatment in addition to the chemical reactions mentioned above. Excessive drying denatures the protein extensively and makes it insoluble. Yet, too high a protein extractability from the sample may be due to abnormal proteolysis as a result of microbial action. In such situations, other evidence should be obtained from other indices, such as TMA or microbial content.

Fat oxidation is another problem of dry fish products, especially those made from oily fish. The rate of oxidation is increased when the moisture content is decreased to a certain extent. Thus, during the drying operation, protective measures will be helpful in retarding oxidation. The addition of anti-oxidants to the raw material prior to drying or drying under atmosphere of low oxygen partial pressure are some of the examples.

With a low moisture content, the dried product may be more susceptible to fungi action than bacterial. Thus, fungistatic reagents such as potassium sorbate or propionic acid may be added to dried products to prevent the growth of molds.

Drying Technology

In order to select an efficient dryer, some basic understanding of the dehydration of fish is essential. Basically, factors that govern the drying performance of food products may be catagorized in sequence as follows: (a) external heat transfer, (b) internal heat transfer, (c) internal mass transfer, and (d) external mass transfer (4). The interaction of these four factors goes on among a heat source, a moisture sink, and the product during the drying process and basically occurs in the listed order. It is usually much easier to achieve high external heat and mass transfer coefficients, because of the required characteristics of the food material which govern the internal coefficient. For this reason, the dryer is usually designed to achieve external coefficients just high enough so that they do not limit the drying rate, but not any higher. The ways to increase the external coefficients are to increase the temperature of the heat source, optimize the direction and velocity of the air flow, reduce the humidity of the air, and improve moisture sink with proper traps such as dessicants or condensers.

Internal heat transfer always occurs through conduction while the internal mass transfer takes place through viscous flow, Knudsen diffusion, and bulk diffusion. The last process is a rate limiting step for fish drying. At an earlier stage when the moisture content of fish is more than 10%, the diffusion coefficient is usually about 10 fold higher than that of the fish with a moisture content between 10 to 1% (3). The diffusion rate increases when the temperature is increased. It roughly rises 50% for every 10 C increase when the fish is dried at 10 C to 50 C. Improvement of the physical structure of fish is another way to increase the diffusion coefficient and thus the internal mass transfer rate. Means such as slow freezing as in the case of freeze drying, treatment with chemicals, or slicing can either increase the porosity or reduce the thickness of fish structure. Physical pressure applied on fish will also accelerate the outward migration of water. The mass transfer rate also depends greatly on the fat content of the fish. Species with similar fat content usually have the same diffusion coefficient. Yet, the presence of fat reduces the diffusion rate of the water. For this reason, the optimum conditions for fish with different fat content should be worked out separately.

The basic optimal drying conditions often cited in literatures are temperature at 20 to 50 C, relative humidity at 50 to 65%, and air velocity at 0.5 to 2 miles per hour. However, in operating a dryer under optimal conditions, there are many approaches using various facilities to increase the efficiency and reduce the energy consumption of the drying operation (1). These approaches include two-stage drying, recirculation of the hot air, recovery of heat from the condenser, solar or geothermal heat, intermittent drying and press-piling, explosion puffing, microwave heating, and use of vacuum, or dessicants. The two-stage operation involves using high temperature, high air-velocity and low humidity during the constant-rate drying period and changing these conditions in the falling-rate drying period when the internal mass transfer takes charge. One of the first two-stage dryers was designed in the early 60's by the Grande-Rivere Technological Station, F.R.B., Canada. The hot air of its second section was supplied from recirculated air used in the first section. A relative humidity (RH) of 50% in the first section resulted in 60 to 65% RH in the second section, which was found suitable for the drying of salted cod. The temperature used in the first section can be higher than the permitted product temperature, because the heat of evaporation taken at the product surface in the drying process reduces the surrounding temperature. This is called the wet bulb depression. Yet, in the second stage, the temperature is lowered and the relative humidity is increased so that the drying capacity is lowered to match the water migration rate of fish and prevent case-hardening. The maximum allowable temperature and the lowest allowable relative humidity in different stages has to be determined for different fish.

There are some other processes such as vacuum or freeze-drying to really produce high quality dry products in a short processing time. Yet, since the goal of this project is to produce exportable products for African and Asian nations, our study has been limited to only those approaches that are economical. In this report, improvement of internal mass transfer is being concentrated. Alternately drying and press-piling the fish has traditionally been considered as one effective way to restore protein quality of the fish surface and prevent it from being case-hardened, which will then keep the drying rate from falling too soon. However, it is labor intensive and slow. The controlled drying by maintaining RH at 50 to 65% cannot speed up the drying rate too much either. An "explosion puffing" method was developed in the early 60's as another effective way to improve the internal mass transfer. To perform the continuous explosion puffing, partially dehydrated food pieces, after a preliminary drying treatment, are heated with superheated steam in a sealed tunnel until the product reaches a certain temperature. The product is then conveyed to a subsequent chamber and discharged instantly to atmospheric pressure into a receiving section. During this process a certain amount of water within microcells of the product is vaporized explosively which leaves a highly porous network of capillaries. This has improved the diffusion rate tremendously. Several studies involving fruits and vegetables have reported that conditions for puffing involved preliminary dried until the moisture reached 19 to 35% (wet basis), equilibrated for 18 to 24 hours, and then heated with steam of 25 to 60 psig with 20 to 70 F of superheating for 2 to 6 minutes before puffing. The product was then dried in a single-stage continuous belt hot air dryer until the desired final moisture content was reached. Factors affecting the quality of the puffed fruit and vegetable products included moisture content of the product before puffing, degree of superheating on steam supply, puffing pressure, and duration of pressurization. A concise review on the subject was done by Holdsworth in 1971 (2). However, not much success has yet been reached by this process on meat products. Dry fish for example, is very much different from dry fruits and vegetables in that proteineous structure is dealt with instead of the network of cellulose and carbohydrates. The difference represents its susceptibilities to heat, strength of the structure, equilibrium rate, and reversibility of the dried structure upon heating and puffing. However, as indicated by the study on fruits and vegetables, this process could greatly improve the quality of the dry product and dramatically shorten the drying time. It seems to be worthwhile to investigate the possible application of this process on fish dehydration process.

MATERIALS AND METHODS

Materials

Fish used for this study was carcass from roe mullet, caught in the northwestern coastal waters of Florida. The roe and gut were extracted at the same area and shipped to us after being frozen. It was stored frozen for about three months before use. It was then thawed, scaled,

and filleted with the skin on and thickness of about 1/2 inches. The size of most pieces was about 3 x 1 x 12 cm^3. The belly parts were all trimmed off.

Preliminary drying

The dryer used in this study was forced air circulated, electrically heated, and humidity controlled. It was originally designed as a demonstration fish smoker having a chamber size of 20 x 20 x 20 inches. The chamber wall was baffled so that linear air velocity in the majority of the space inside was about 40 to 60 ft/min (R. T. Toledo, unpublished data). The drying temperature and relative humidity used were 50 C and 50%. When the desired moisture content was reached, the sample was then kept at 5 C for about two days before subjected to puffing. In one case, the sample was puffed right after pre-drying. The relative humidity was controlled by a system composed of a steam generator, a hygrometer indicator with a recorder signal output (American Instrument Co., Silver Springs, Maryland), a humidity sensor matching the indicator, a chart recorder, a photoelectric detector having a low power output controllable by the detection (Electric Eye Products, Co., N.Y., N.Y.), a relay, and a solenoid valve for the steam jet inside the dryer. The pressure of the steam supply was set at 10 psig, which offers two branches of steam lines into the air duct of the dryer; one was controlled by the humidity reading, the other stayed open and served as the constant steam supply to dampen the humidity difference between the opening and closing of the controlled line. This control started from the humidity sensor, the hygrometer, the recorder, the recorder pen mounted with a reflector, the photoelectric detector, the relay, and finally to the solenoid valve of the controlled steam line. This mechanism enabled us to maintain a relative humidity of $\pm$ 1.5%.

Explosion puffing

A small bench-top puffing gun was made with 16 H x 6.4 dia. cm stainless steel cylinder. It had a cap screwed on one end with a 1/8" NPT steam inlet fitting and a 2" Evertite quick disconnect nipple and cap fitted on the other end. A steam outlet was installed on this end for bleeding the air at the beginning of each cycle. In case of the superheated steam, a gas-heated heat exchanger for superheating the incoming steam was installed between the steam supply and the puffing gun. Two 30-gauge copper-constantan thermocouple wires were also planted into the chamber to monitor the product and chamber temperature. To conduct the explosion puffing, the gun was first flushed with steam for preheating. The steam was stopped for loading. The predried and equilibrated sample was then put into the chamber. The cap was closed and the heating was started by turning the steam on, bleeding the chamber, and then closing the outlet. After the desired product internal temperature or heating time was reached, the quick disconnect was opened and the pressure was reduced to atmospheric pressure instantly.

Final drying

The puffed sample was dried in the same dryer mentioned previously. All conditions were the same as the preliminary drying except the relative humidity was increased to 55%. In one treatment, the humidity controlling system was stopped and the sample was dried under about 3% relative humidity.

Quality evaluation

The weight loss of the drying process was monitored by a continuous weight sensing system composed of a cantilever beam type load cell with 25-lb capacity (Sensortronics, Covina, Calif.) and a scanning pyrometer (Newport Lab, Santa Ana, Calif.) used as the A/D converter. It could produce a maximum of 75 mv signal output with a maximum 15 VDC of excitation input power when 25-lb load was applied. An output signal was 3 MV per pound at this condition. Calibration curves produced from different input voltages are shown as follows:

Equation: $Y = BO + B1 \cdot X + B2 \cdot X^2$

Input (Volts)	BO	B1	B2
3.5	27.9974	18.2713	-0.0745
6.5	35.5232	37.1989	-0.6308
14.4	51.9695	73.6799	-1.5108

Y: Relative readings for load cell output
X: Weight applied, Kilogram

As shown in Figure 1, the curve with 3.5-volt input was better for measuring heavier weight loads. The one with the 14.4-volt input could be used up to 5 kg due to the range limitation of the A/D converter. The latter also came with greater noise, especially when small weight was measured. Thus, the one with 6.5-volt input was chosen for this study which could produce an output signal of 10 mv when 6000 grams of weight was applied.

Rehydration property of the product was also measured by percent weight increase after boiled for certain period of time. Boiling longer than the 5 minutes suggested by the literature (5) was studied due to the consideration of the fact that dry fish might require different boiling time to show its rehydration capacity.

RESULTS AND DISCUSSION

Conventional air drying of roe mullet fillets

To examine the drying property of roe mullet fillets, a batch of fillets was air dried under 50 C, 50% RH, and 0.5 MPH air velocity for first ten hours and increased to 55% RH afterwards. The drying curve is shown on Figure 2. It took 45 hours to reach 10% moisture content. The drying rate started to fall at about 38% moisture after 15 hours drying. The product was a little darker than the stockfish made from cod, due to the dark meat present in mullet and the higher drying temperature used. Yet, it looked as lean and possessed the same typical dry fish flavor as the traditional dry fish. Addition of TBHQ by dipping the raw material

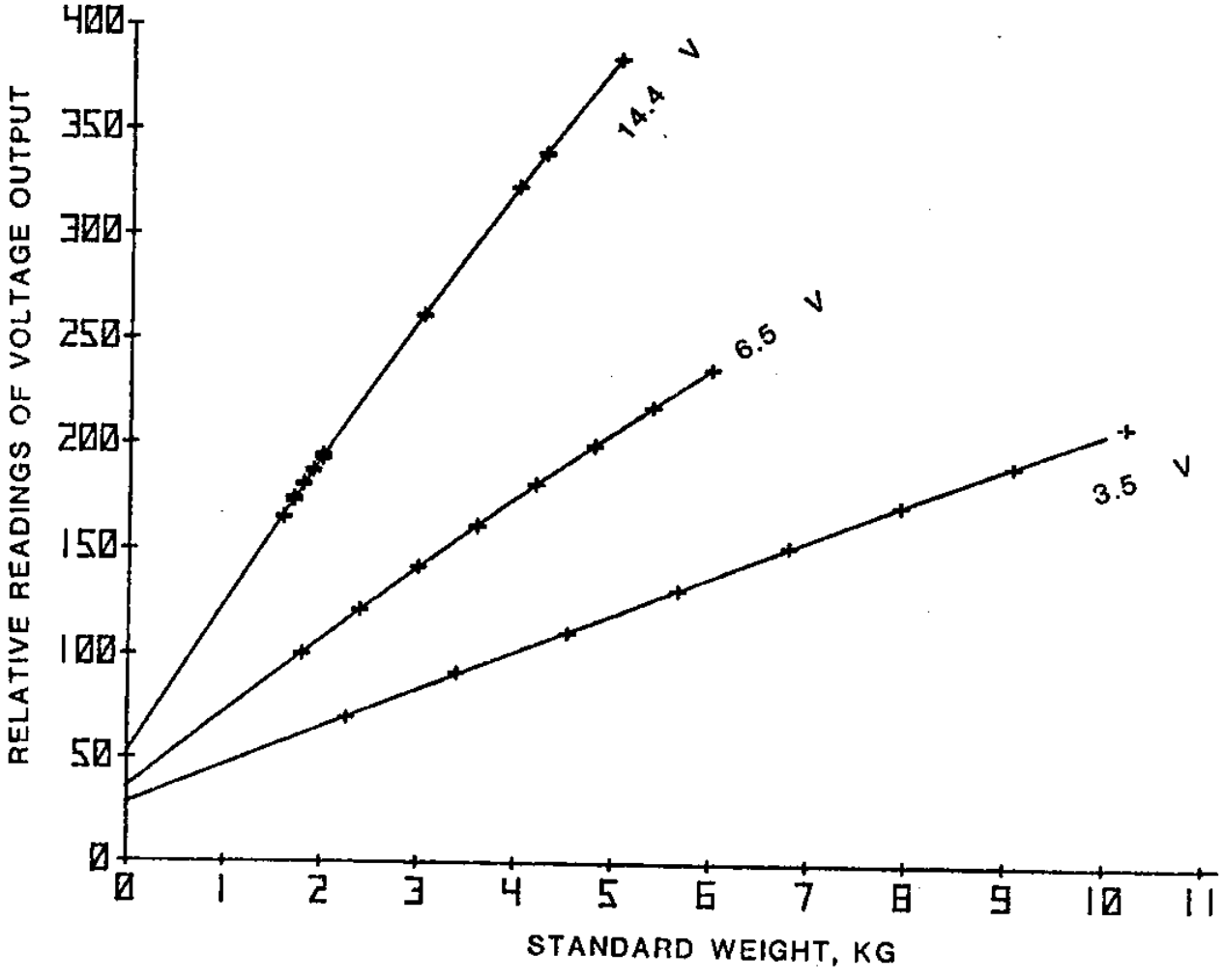

FIGURE 1. Calibration curves under different input power for the load cell with 25-lb capacity.

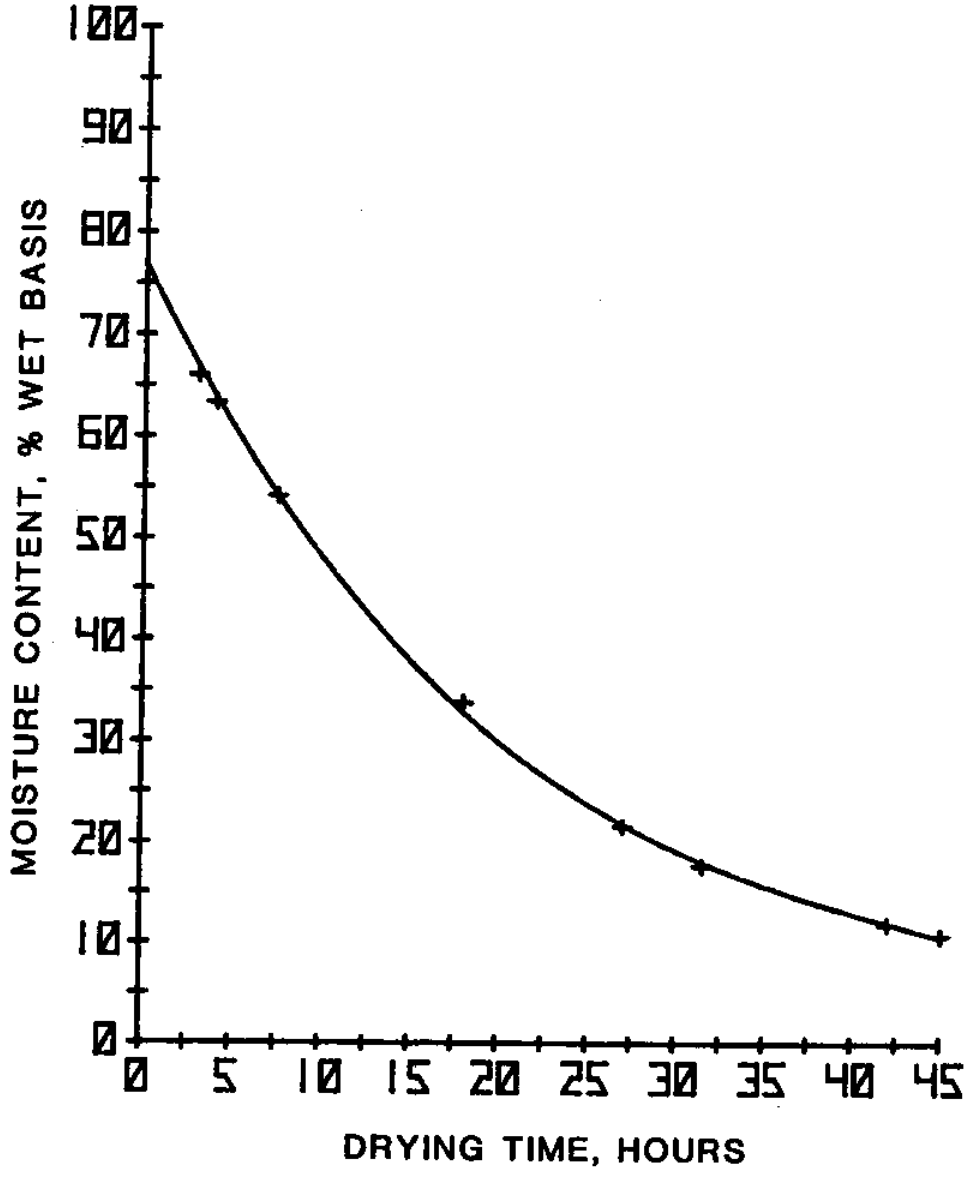

FIGURE 2. Decrease of moisture content during the drying of roe mullet fillets under the conventional drying process using 50C, 50-55% relative humidity, and 0.5 MPH air velocity.

in 0.02% solution did not affect the color, yet less rancid odor was detected in the dipped product. Possible fat oxidation during storage is being investigated. Means of control for these problems of color and rancidity are critical.

Factors affecting the puffing of fish

When the moisture content of the predried fish was higher than 55%, the fillet structure could be easily burst apart by puffing with steam of 35 psig or higher. However, when the moisture content was 35% or lower, the fillet surface could easily be burned by both saturated or superheated steam of 35 psig or higher. Since the falling rate period seemed to start at about 38% moisture, the puffing treatment would be beneficial to be conducted at this period to extend the constant rate period. Steam with pressure lower than 25 psig did not appear to puff the predried fillet of any moisture contents. Steam with pressure higher than 45 psig would either burn fillet surface with moisture less than 35% or burst fillet with moisture higher than 55%. Superheated steam of any pressure values would brown or burn the fillet surface readily. Superheated steam seems to provide dry heating which cannot be standed by the proteineous material of the fish fillet. Thus, saturated steam may be the better heat and pressure source for puffing this type of product. Furthermore, the saturated steam may also provide moist heating which will rehydrate the fillet surface quickly. This may lead to the moisture equilibrium step to be shortened or eliminated.

A treatment using 40 psig saturated steam and 30-second resident time did successfully puff the predried fillet of 45% moisture. In this condition, the internal temperature of the product did not exceed 70 C, yet, the action was sufficient to rehydrate the surface and swell up the fillet. However, with the same conditions except the resident time became 4 minutes or longer, the browning of the surface was observed and the swelling of the fillet was actually diminished.

Final drying

Three batches of puffed samples were used to dry to the final stage; (i) fillets of 55% moisture puffed by 25 psig superheated steam for 5 minutes, (ii) fillets with 45% moisture content puffed by 40 psig saturated steam for five minutes, and (iii) fillets of 45% moisture puffed with 40 psig saturated steam for 30 seconds.

Case 1: The fillets with 55% moisture content puffed by 25 psig steam superheated by 56 F over the saturated temperature after the internal temperature reached the steam temperature was further dried to the desired 10% final moisture content. The drying conditions were 50 C, 55% RH, and 0.5 MPH air velocity. The drying curve was as indicated in Figure 3. The moisture content was decreased in the puffing step. The drying rate slowed down however after this treatment. It is suggested that prolong heating under superheated steam has actually denatured the protein at the surface and further enhanced the problem of case-hardening. Since this had occurred to the fillet with high moisture content (55%) and by the low pressure steam (25 psig), studies with lower moisture contents and higher pressure became unnecessary.

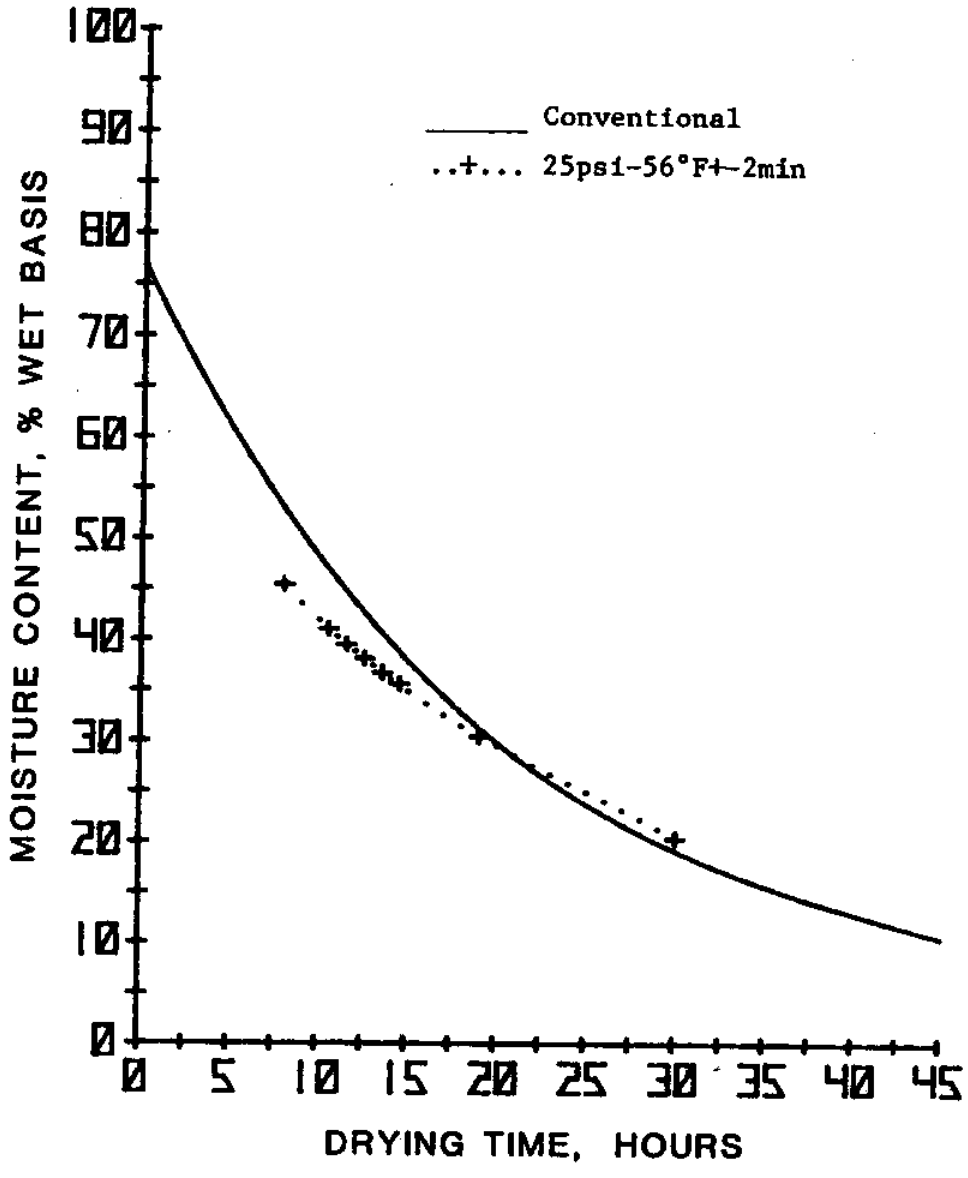

FIGURE 3. Decrease of moisture content during the drying of roe mullet fillets under the conventional drying and the explosion puffing drying processes. Conditions for the puffing was 25 psig steam superheated for 56F with about two-minute resident time.

Case 2: The sample was puffed with 40 psig saturated steam after heated for about five minutes when the internal temperature of the fillets became the same as the steam temperature. The surface was slightly browned. A hard shell was formed at certain areas of the surface. The drying curve was as shown in Figure 4. The drying conditions were the same as in Case 1, except that the steam supply for the humidity control was closed and the relative humidity was about 3%. It was assumed that if the outer surface had been overheated and coaggulated, further formation of case-hardening might be minimal even when the accelerated drying was conducted under a low relative humidity. It was shown that although the moisture content was reduced right after puffing, the drying curve was still about parallel to the conventional drying, meaning that the drying rate was about the same whether the sample had or had not been puffed. The overall drying time to reach 10% moisture was about 40 hours, slightly shorter than the conventional drying.

Case 3: The sample was puffed in the same conditions as the Case 2, except that the resident time was only 30 seconds instead of five minutes. The drying conditions were the same as the Case 2. The drying curve (Figure 5) showed that the drying rate was greatly improved. The overall drying time was about 30 hours, representing a 15 hours saving over the conventional drying.

Product quality and rehydration rate

The rehydration rate of products made from Case 2, 3, and the conventional drying studies were examined. The rehydration properties were measured by the rehydration coefficients, percentages of weight increases over the dry product. About 25 grams of samples were boiled for about 20 to 30 minutes before a maximum value was achieved. Rehydration of dry fish seems to take longer than the dry fruits and vegetables. Coefficients thus obtained for samples from conventional drying, Case 2 and Case 3 were 55.5%, 71.3, and 63.5%, respectively. Both puffed samples had higher rehydration coefficients than the unpuffed one. The sample from Case 2, which had a 5-minute resident time in the puffing gun, showed a higher rehydration coefficient than the sample from Case 3. Since the product made from the Case 2 study had 8.9% moisture content vs. the 3% for the sample from Case 3, this difference was suspected as the cause for difference in the rehydration property between the two puffed ones. The sample with lower moisture content was harder to be rehydrated than the one with higher moisture content, even when the one with lower moisture content was puffed at a milder condition.

Besides this difference in rehydration coefficients, differences in appearance and flavor of the products were also observed. The puffed product always had a smoother surface and less shrinkage than the unpuffed sample. The structure strength of the puffed sample was also weaker, crispier, and easier to be broken apart. However, there was milder dry fish flavor in the puffed product than the conventional one, probably because the heat treatment had denatured the autolytic enzyme system in fish prematurely. The flavor development during the long-

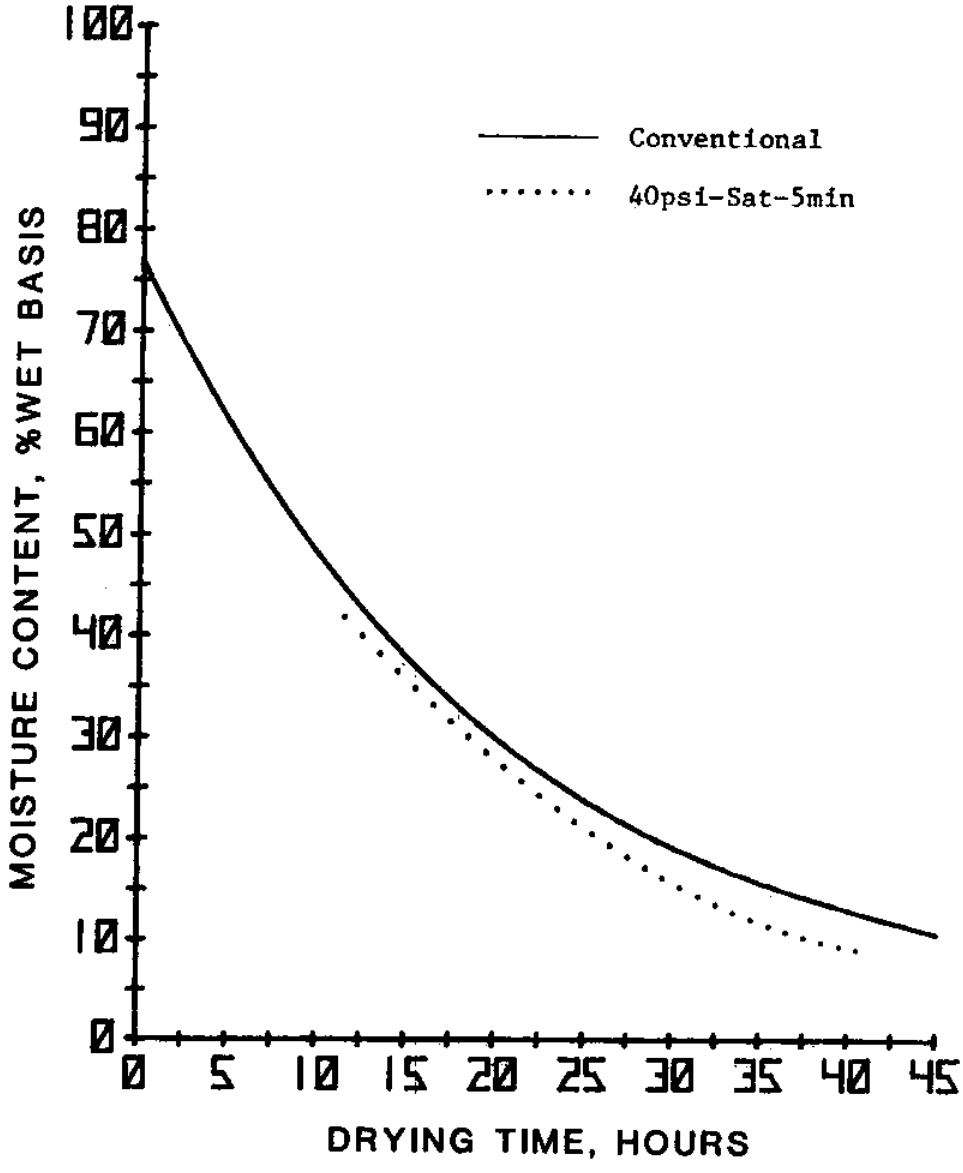

FIGURE 4. Decrease of moisture content during the drying of roe mullet fillets under the conventional drying and the explosion puffing drying processes. Conditions for the puffing was 40 psig saturated steam with about 5-minute resident time or until the internal temperature reached the steam temperature.

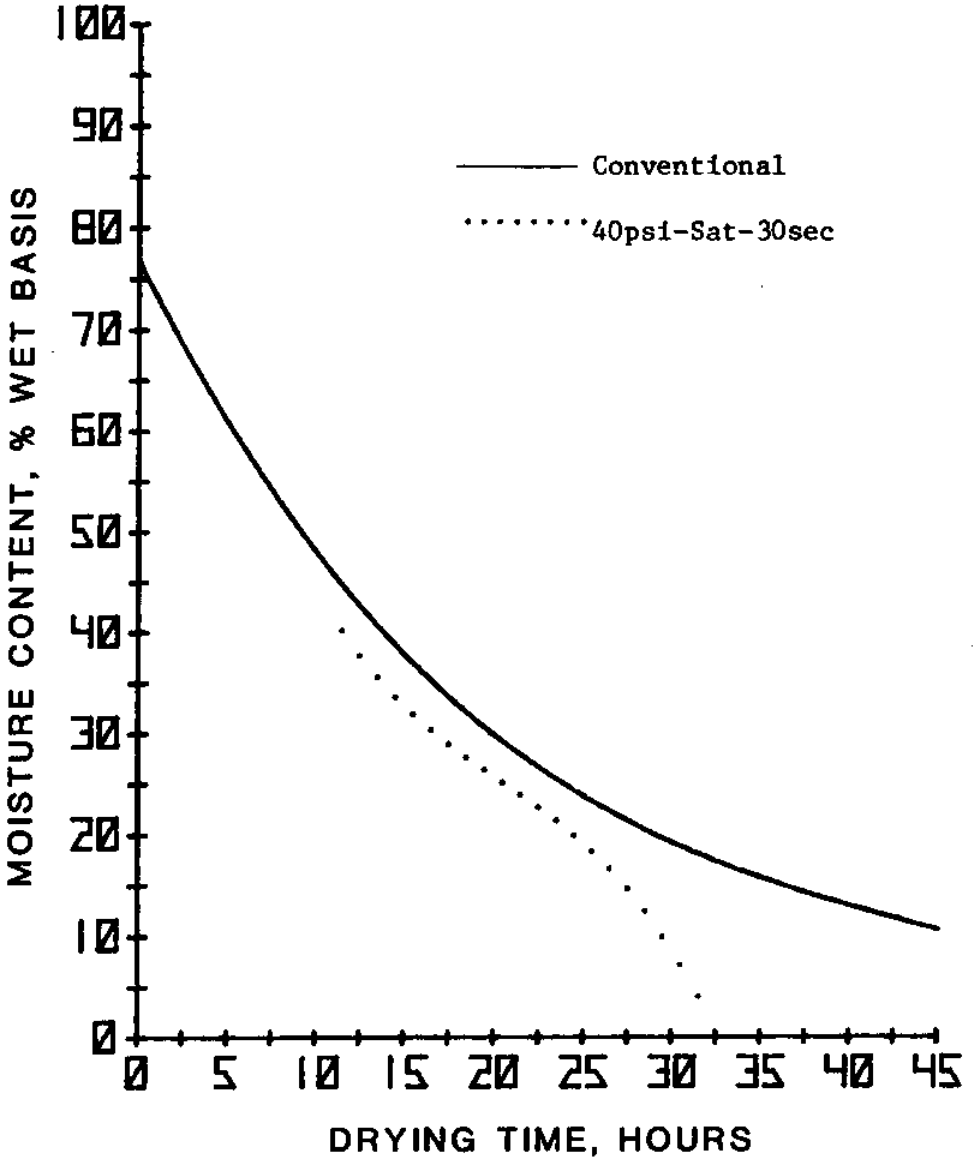

FIGURE 5. Decrease of moisture content during the drying of roe mullet fillets under the conventional drying and the explosion puffing drying processes. Conditions for the puffing was 40 psig saturated steam with 30-second resident time.

term storage requires further study. There was little difference in color, yet, the puffed product always looked oilier than the unpuffed one. The lipid in the fillet seems to be released by the heating and puffing treatment. Its effect on the product rancidity requires further attention.

In conclusion, the explosion-puffing did prove to improve the drying time, product appearance, and rehydration property of dry fish. These advantages suggest that a designed experiment is necessary to study the optimum conditions for explosion-puffing the dry fish products. The effect of this treatment upon the quality and storage stability of the dry fish required further study. The consumer acceptibility of the product and the economic feasibility of this process should also be eventually examined.

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PROTOTYPE COOKERS FOR INVESTIGATING AQUEOUS COOKING OF DRESSED OR WHOLE FINFISH

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Sea and Sound Processing Co., Inc.[3]; Empire Menhaden Co., Inc.[4]
and Tom Thumb, Inc.[5]

INTRODUCTION

This is a summary of the final project report concerning prototype aqueous cookers for finfish, conducted by Wallace Menhaden Products, Inc., Metairie, Louisiana, from November 1, 1979, to April 30, 1981, under Contract No. 11-04-25900, issued by Gulf and South Atlantic Fisheries Development Foundation, Inc., Tampa, Florida. Matching funds were provided by the companies listed above.

Processors of food fish, and manufacturers of fish meal, fish solubles and fish oil have many identical problems in protecting those nutrients which abound in finfish. Improper processing conditions can adversely affect proteins and lipoids, reduce yields, and increase the energy required to operate the plant. While there is need for much more research directed at exploring the complexities of finfish cooking, the more urgent need is for simplification of what is already known and guidance in making use of the information.

It was reported by Angel and Miller (1) that the Wisconsin Fish Boil Method (3) is an effective cooking technique, involving immersion of the dressed, raw fish in boiling 8% saline solution. A spray-type cooker, which would use the aqueous extracts of finfish instead of saline solution, was suggested.

The present project started with the assumption that cooking finfish in the presence of such aqueous extracts could lead to better control of the cooking process and reveal improved approaches to saving energy. Most of the effort was to be directed at designing and building equipment for demonstrating what could be accomplished, then indicating how processors, regardless of size, could proceed independently to make improvements.

Aqueous cooking of finfish for human consumption offers many options. Boiling water can be used for skinning and removal of subcutaneous fats, the fillets or dressed fish remaining in substantially raw condition. Complete and uniform cooking can be accomplished at reduced temperatures. Surface fats can be removed and recovered from the cooking medium while the aqueous extracts can be returned to the meats, or concentrated and used as separate ingredients.

One can be more receptive to the idea of aqueous cooking if it is fully understood that the materials that are produced are likely to be intermediates intended for further processing. Examples include fillets or dressed finfish from which surface fats and skins have been removed;

flakes and boneless chunks of meat; precooked finfish steaks; aqueous finfish extracts; and finfish fats.

Recycling and utilization of aqueous extracts of finfish intended for human consumption can result in as much as 25% additional edible protein. Similarly, Christmas and Etzold (2) provided a flow sheet of the wet reduction process applied to menhaden in which 76% of the total protein went to the fish meal, and 24% went into the stick water which was then evaporated to produce condensed fish solubles.

The possibility that stick water, the aqueous extract of whole finfish, can act as a heat transfer medium to improve the cooking of the raw material has important implications for processors of industrial finfish. These companies are using either (a) direct heat cookers which depend upon live steam injection or (b) indirect cookers with steam heated conveyor troughs and screws. The industry is aware that direct heat cookers waste steam in addition to introducing about 300 pounds of condensate for each ton of fish processed, placing an additional load on the evaporators. As to the indirect cookers, Pigott (4) and others have reported formation of scale on the heating surfaces which reduces output and efficiency.

In 1977, Sand (5) discussed the possibility of a low temperature process in which liquid from the presses would be partly recycled back to the cooker and involving cooking to temperatures of 50 - 60°C (122 - 140°F). This was based on the observation that oil separation improved at the lower temperatures. Urdahl (7) stated recently that work is still in progress, adding that, "The project was stopped mainly because of lack of a suitable heat exchanger which could heat the fish to the exact temperature we needed to get the effect of the process." He reported that heat exchangers for fish are being sold by SAAS-Process A/S and by Stord Bartz A/S, such equipment being used to extend the capabilities of existing cookers, or to serve as cookers.

MATERIALS AND METHODS

Pilot plant and Model 1 prototype cooker

The facility shown in Figures 1 and 2 is located in a 900 sq. ft. area at Sea and Sound Processing Co., Inc., Beaufort, North Carolina. It consists of (2) an autoclave unit for steaming raw materials at atmospheric pressures up to 20 lbs. p.s.i., (b) a heater/evaporator unit for rapidly elevating the temperature of aqueous extracts, or evaporating to required concentrations, (c) an elevated surge tank with closed steam coils for holding liquids at desired temperatures, (d) a steam jacketed kettle as an additional surge tank, or for preparing aqueous extracts of finfish, or cuttings, and (e) the Model 1 prototype cooker. A large processing table is provided between units (a), (b), (c), (d) and (e).

There is adequate steam supply from the processing plant boilers, and the pilot plant is connected directly to the stick water supply. Numerous liquid circulation options are provided by interconnecting pipes and valves, a pump, and by gravity flow.

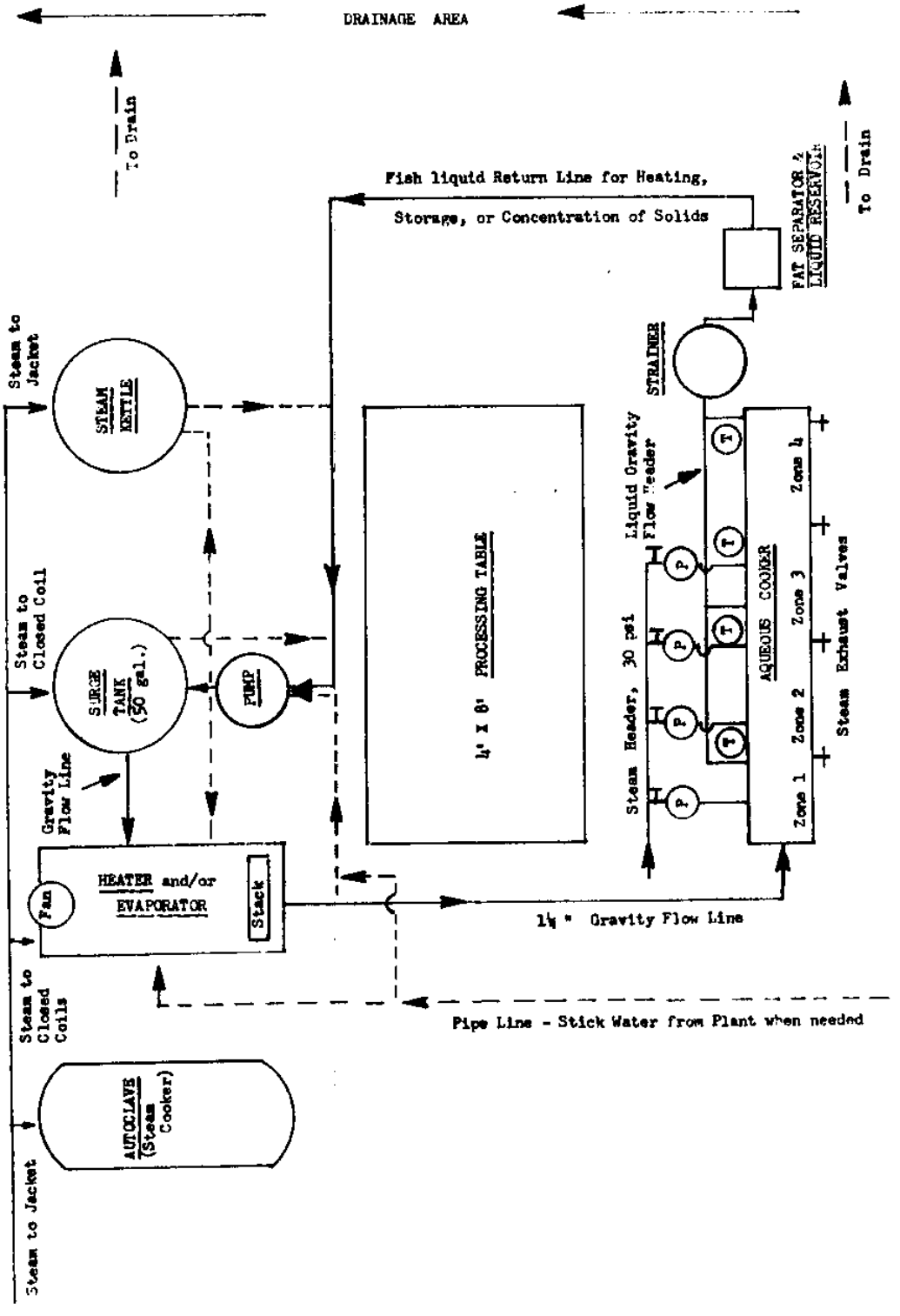
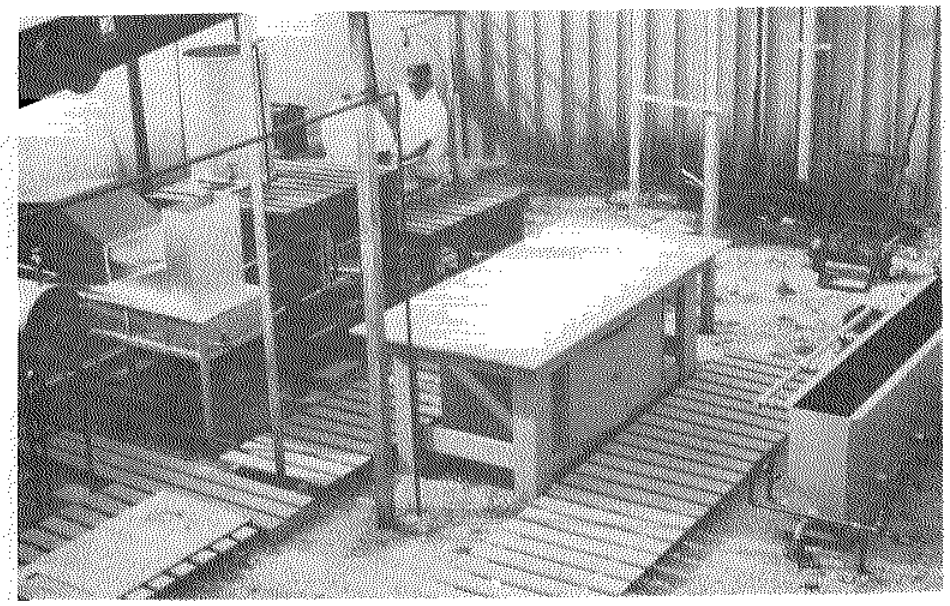


FIGURE 1. Pilot Plant Layout, Beaufort, N.C.



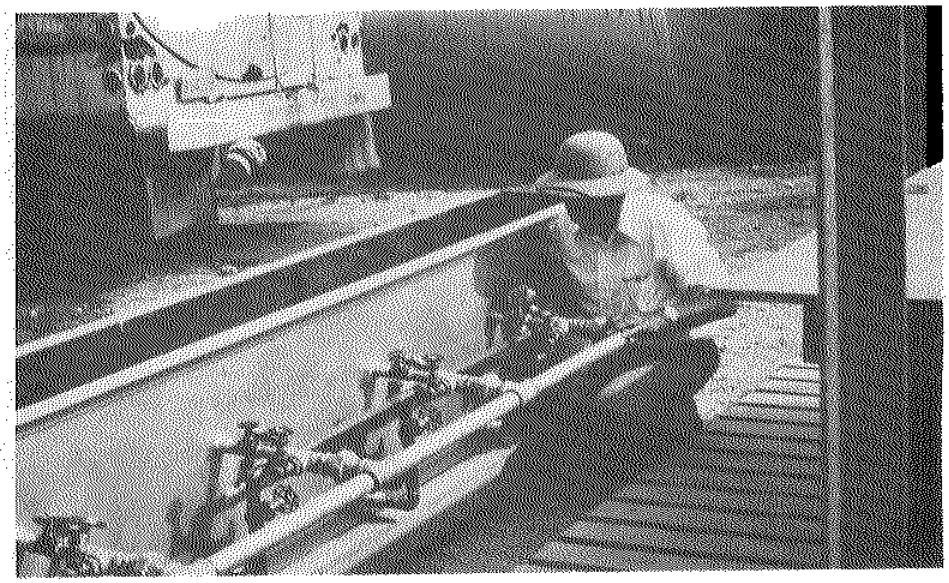


FIGURE 2. General View of Pilot Plant (top).
Model 1 Prototype Cooker (bottom).

The Model 1 prototype cooker is basically a tank made of 12-gauge mild steel, having inside length, width, and depth of 8x1x2 feet. Four separate banks of heating coils run crosswise on the bottom, creating distinct heating zones. Overflow vents for each zone are located one foot above the coils. In lieu of conveyors, baskets with one cubic foot capacity can be introduced at one end of the cooker at specified intervals, and removed at the other end. Cooked materials are drained and sometimes rinsed on stationary, or vibrating screens located on the processing table. The aqueous extract cooking medium can be made to flow in a concurrent or countercurrent direction or introduced at a number of other points.

Model 2 prototype cooker

The stainless steel unit shown in Figures 3, 4 and 5 is installed in the Riverview Crab Company plant at Oriental, North Carolina. Its design results from experience gained in operating the Model 1 prototype cooker. Recognizing that small plants must conduct a variety of operations in limited space, it is compact, weighs about 400 pounds, and can be used for aqueous extractions, blanching, fat separations, pasteurizing, steaming, sterilization, as well as for aqueous cooking.

The basket supports, located just above the V-bottom, are for holding 24 nickel-plated stacking utility baskets, each measuring 12x18x20 inches and capable of holding up to 15 pounds of raw material. So far, only two layers of baskets have been used, six baskets per layer.

The aqueous cooking medium is held at a selected depth by attaching one of three metal dams which control overflow into a 10x11x20 inch tank built on one end of the cooker. This tank holds about five gallons at a depth of one foot, providing a convenient way to separate aqueous liquid from fat.

Objective trials

Thermal properties of the heater/evaporator, and of the two prototype cookers, were measured by using known amounts of water, or menhaden stick water, and determining heating and evaporation rates.

Laboratory experiments included the setting up of several small scale cooking systems for closer examination of species variations, shapes and sizes, time and temperature, and heat penetration. The performance of aqueous finfish extracts, with and without phosphatides, was compared. Moisture and fat retention of the cooked meats was investigated in terms of such unit operations as rinsing, spraying, screening, centrifuging, pressing, which might follow cooking.

Subjective trials

Aqueous extract of flounder frames, trash fish stick water, and menhaden stick water were used as the cooking mediums. The raw materials tried in the cooking tests were whole menhaden and trash fish, and dressed gray trout, bluefish, mullet, and croaker. Acceptable cooking was estimated by examining flesh texture, meat separation from skin and bones, and absence of raw spots in the vertebra. Completeness of menhaden cooking was checked by pressing out some of the retained stick water, reheating it to the temperature of the cooking medium, and observing its clarity.

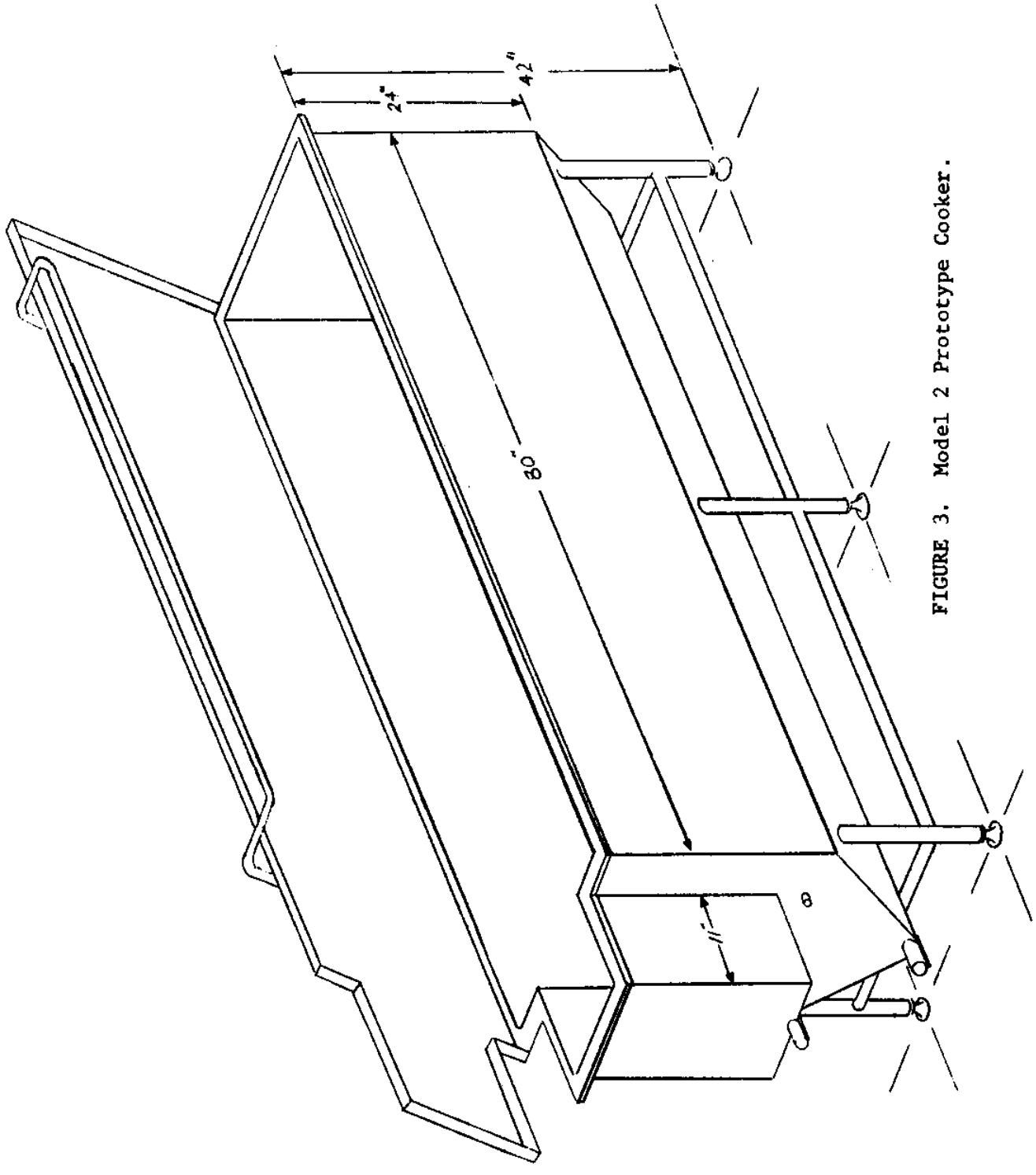


FIGURE 3. Model 2 Prototype Cooker.

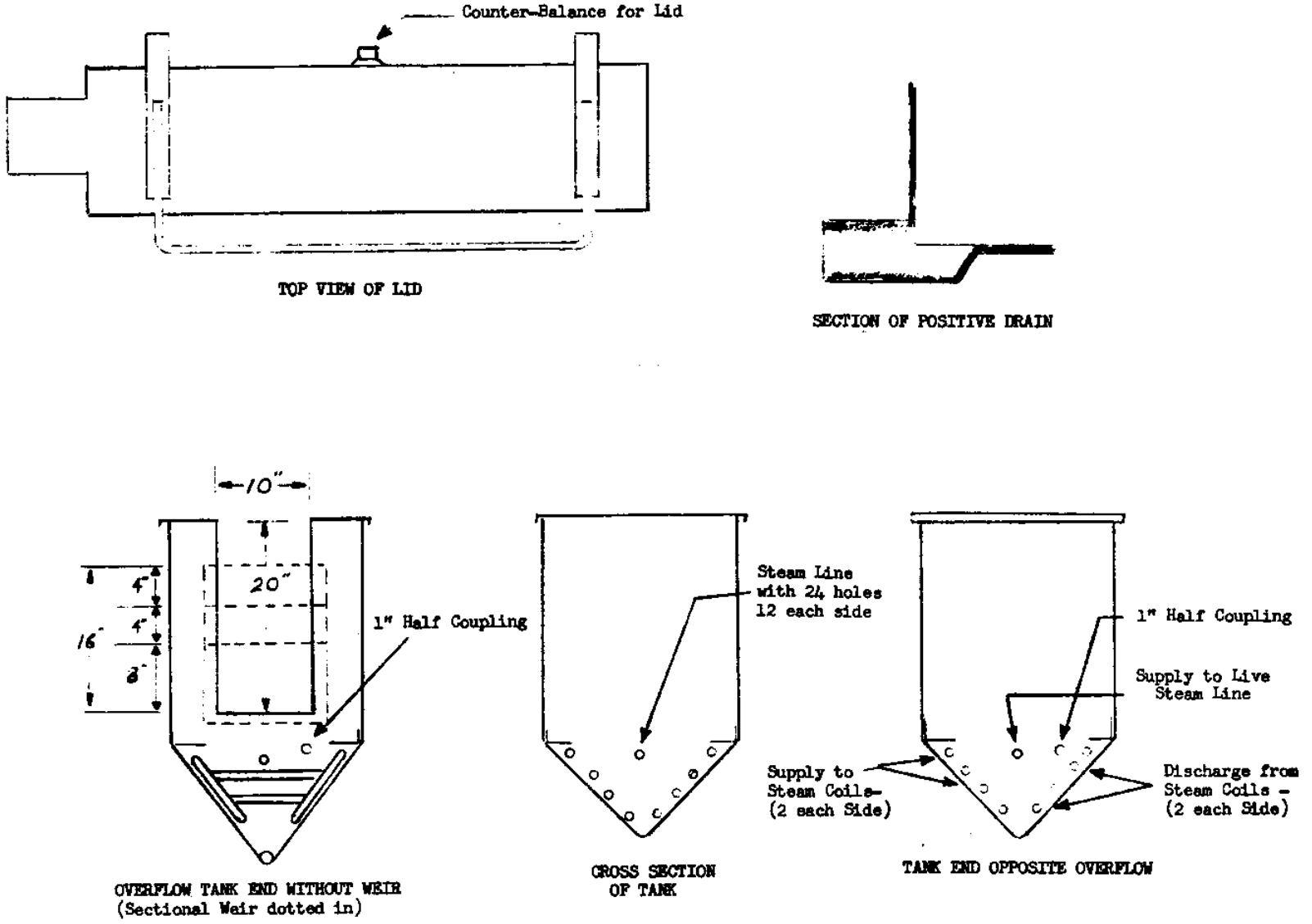


FIGURE 4. Details of Model 2 Prototype Cooker.

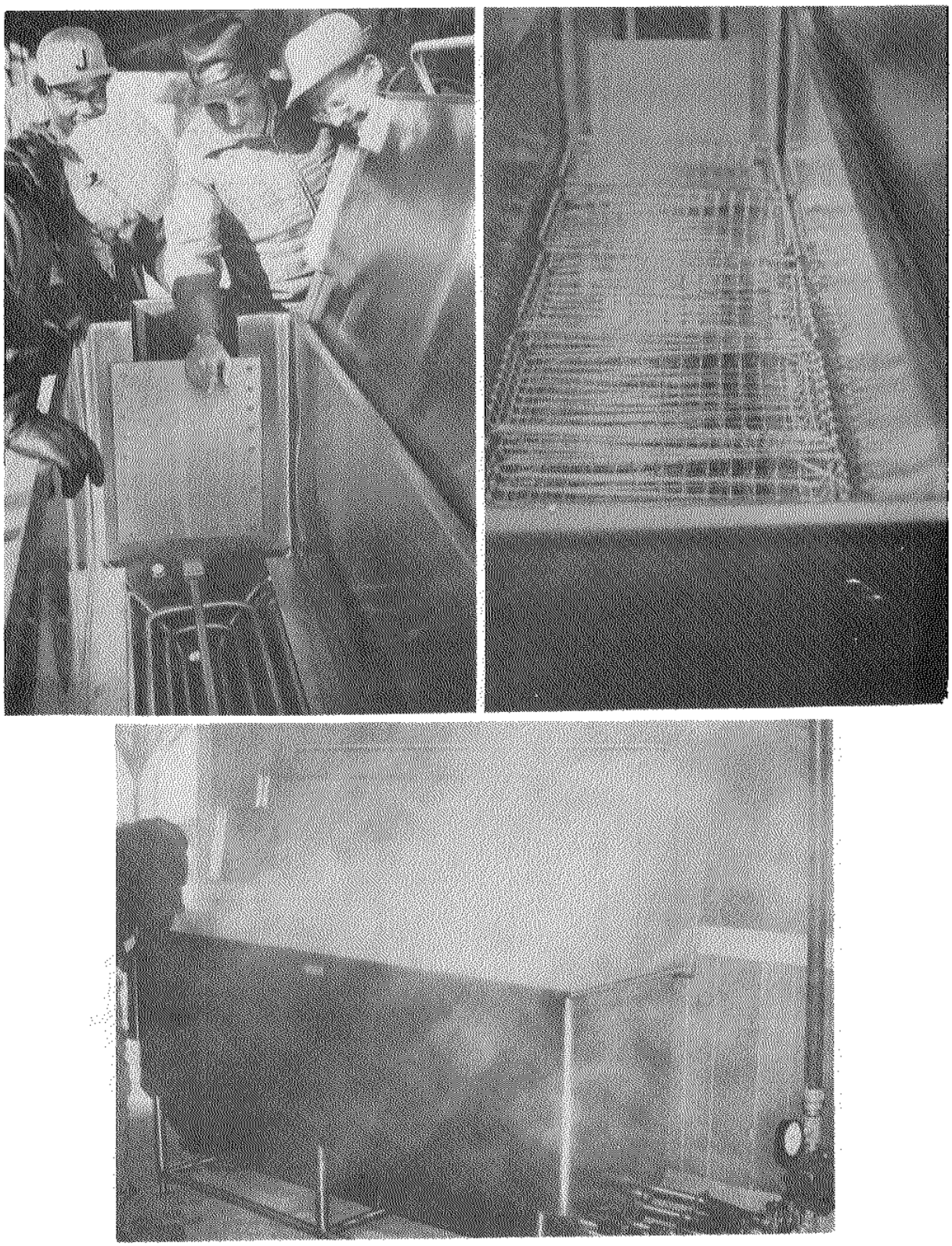


FIGURE 5. Three Views of Model 2 Prototype Cooker: Inside Views Show Overflow Dam, Coils and 2-Layer Basket Arrangement (top). Evaporation Trial Is Shown in Bottom Photograph.

Ten and 20 pounds of finfish per basket appeared to be equally cooked when held 16 minutes in boiling cooking medium. The time requirement was almost double when the cooking medium was at 70°C (158°F).

The heater/evaporator was used to concentrate one ton of menhaden stick water to 50% condensed fish solubles. The Model 2 prototype cooker was used to produce a concentrated aqueous extract of clean flounder frames, finally brought to 35% solids in a laboratory evaporator to arrive at a palatable gelatin-like concentrate.

Engineering information resources

A search for information on cookers was conducted by Technical Information Center, The D.H. Hill Library, N.C. State University. In addition, the equipment development efforts were evaluated by Engineering Advisory Services, School of Engineering, N.C. State University.

Stainless Steel Fabricators, Inc. built the Model 2 prototype cooker, their experience in building food handling equipment being a large factor in its design. A limited number of manufacturers of shaker screens, heat transfer units, small food handling centrifuges, oil skimmers, air-agitated cookers, hot water blanches, and indirect cookers were selected for coverage in the final report because of their experience with food handling processes in related fields. A manufacturer of a large variety of heat exchangers and evaporators was asked to examine the potential for applying the latest engineering concepts to the improved cooking of large quantities of menhaden.

RESULTS AND DISCUSSION

In performing the thermal output trials employing (a) water, and (b) 6.5% solids stick water, the rates of heating and evaporation were about the same, the following heating capacity figures applying to (2) and (b):

	Heater Evaporator	Model 1 Cooker	Model 2 Cooker
Coil heating surface (sq. ft.)	15.11	7.32	13.08
Number of coils	1	4	4
Thermal output, using steam	211,700	244,020	339,824
at 20 p.s.i., BTU/hr	244,019	290,500	354,040

Performance of the Model 1 prototype cooker was within 80% of the thermal output of an instantaneous hot water heater described by Stoever (6), when compared in terms of relative heating surfaces provided by the coils. Such reference points in the literature are hard to find; the problem of predicting the effectiveness of an equipment system for elevating the temperature of a raw material, at times becoming very complex.

The prototype cookers and supporting equipment proved effective in showing how aqueous cooking can be applied to a number of species and sizes of finfish to produce intermediates capable of extending the range of further processing operations directed at human food applications. Future experiments should be designed with the end uses in mind, but there is guidance in what has already been determined.

The heat transfer mediums were readily held at any desired temperature up to boiling. Dressed finfish remained separated and receptive to uniform heating, remaining intact and with the meats in the 62 to 68% moisture range. Of the solids (exclusive of fat) present in edible trimmings and bones from dressing operations 10% was extracted by cooking in water, the aqueous extracts then being enriched by recycling up to four times while cooking dressed, raw finfish.

Fat recovery during aqueous cooking of dressed finfish appeared to come mostly from deposits in the peritoneum, the skins appearing to hold back the free oil. Removal of skins after cooking, and spraying of flesh surfaces with hot aqueous medium will remove additional fat sufficient to reduce lipid levels in mullet and trout fillets by more than half.

It was shown that whole fish can be cooked at much lower temperatures than those normally applied to direct and indirect cookers, the aqueous cooking medium providing more uniform cooking and control. Whole menhaden subjected to aqueous cooking remained intact and required breaking before using shaker screen and press for adequate fat removal. Longer retention time will be required if the process becomes less heat intensive. In Norway, it appears that this additional holding time is being provided by equipment designed to preheat the fish.

Stick water with high phosphatide content did not appear to be a suitable cooking medium, but the clear layer of stick water that separates from press liquor when its passage to the centrifuges is delayed, appears to be a promising cooking medium for recycling back to the incoming raw fish, as shown in Figure 6. It is likely that this recycled stick water can be passed through heat exchangers and other devices as a means of injecting heat back into the cookers.

CONCLUSIONS

This project has suggested cooking alternatives for dressed finfish which may improve and extend the end uses and save energy. The Model 2 prototype cooker and some of the small scale equipment which can be used as adjuncts should convince seafood processors that they can afford to be innovative in expanding their capabilities for further processing.

At the other extreme, this study has attempted to provide processors of industrial finfish with a tangible starting point for improving their present cooking operations. Manufacturers of fish reduction equipment, especially in view of what has been developed in Europe, should be able to offer useful advice. Similarly, manufacturers of heat exchangers, evaporators, blanchers and other heating devices for the food industry may have a lot of engineering expertise and closely related experience to make available.

ACKNOWLEDGEMENTS

Ms. Pat Tester, Ph.D. candidate, Oregon State University, presently employed by NMFS, Rivers Island, N.C., for her excellent laboratory work at the Marine Chemurgics facility in connection with this project.

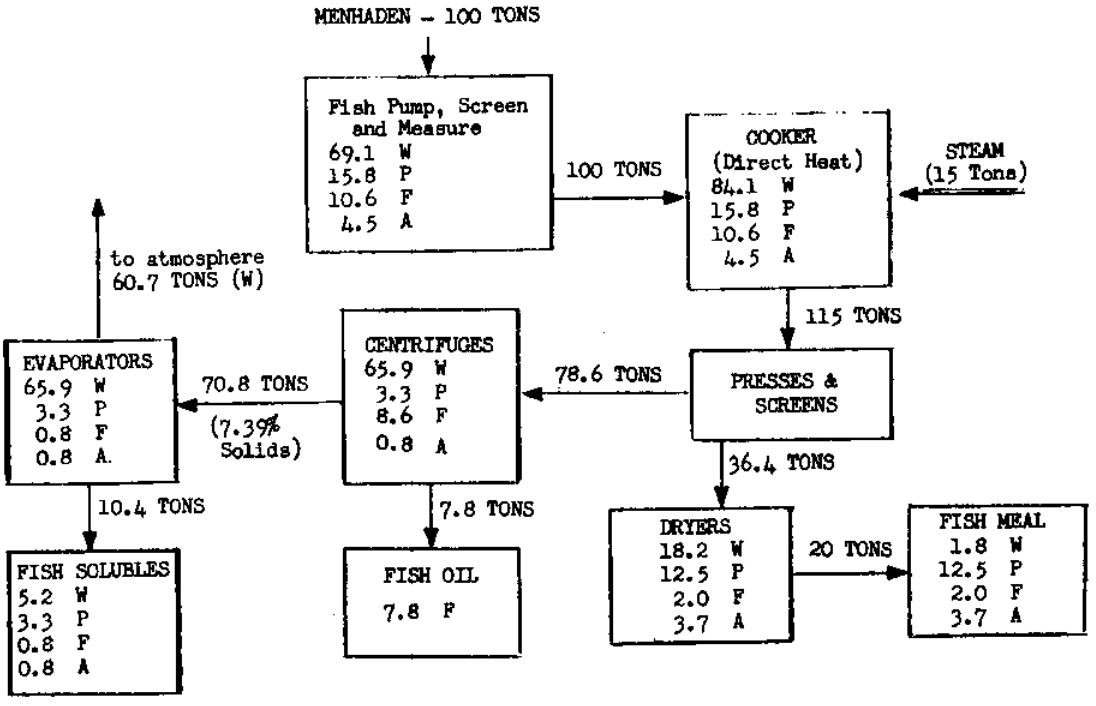
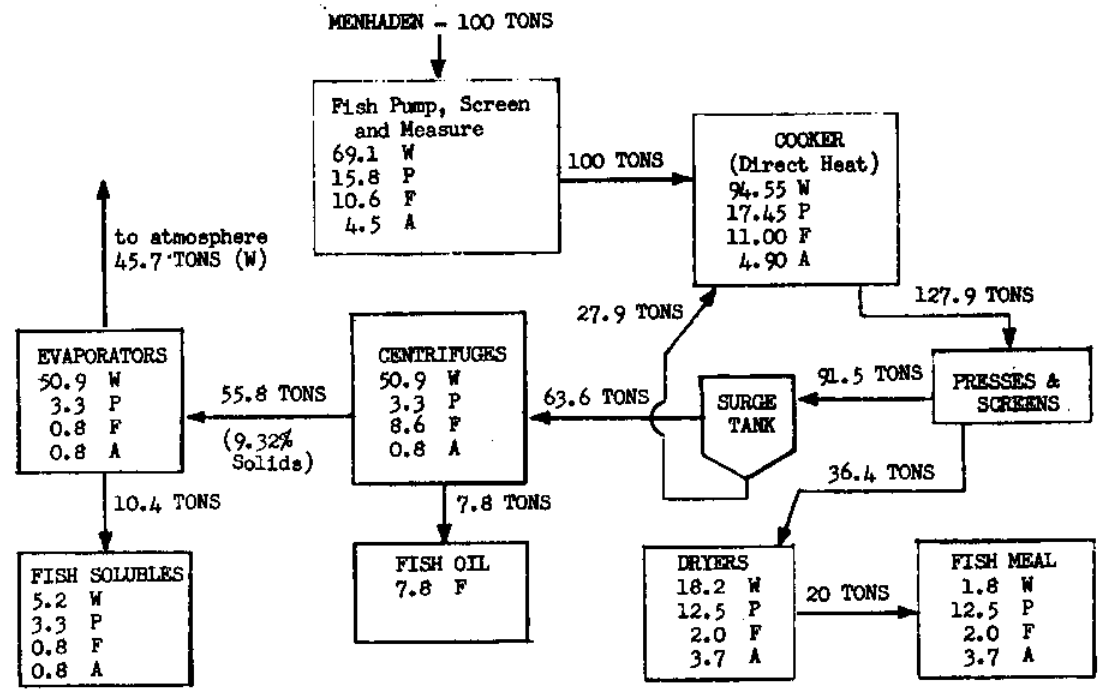


FIGURE 6. Menhaden Wet Rendering Process Material Balance. Above: Using Steam Injection Cooker. Below: Proposed Recycling and Applying Thermal Energy to Stick Water.



(Legend: W = tons water; P = tons protein; F = tons fat; A = tons ash.)

Dr. J.D. Fowler, Engineering Advisory Services, School of Engineering, N.C. State University, for his review of the pilot plant and Model 1 prototype cooker designs.

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Permission to use certain equipment pictures appearing in the full report was provided by the following persons and companies:

Bepex Corporation, and Rietz Manufacturing Division (Mr. Dale Herron) - The Bepex Thermascrew; Rietz Water Cookers with paddle or screw conveyor discharge.

Bock Laundry Machine Co. (Mr. John K. Clement, Jr.) - Bock Centrifuge for Meats and Poultry.

Chester-Jensen Company, Incorporated (Mr. James F. Donovan) - Model P-1 Air-Agitated Cooker.

Oil Skimmers, Inc. (Mr. Thomas M. McLaughlin) - Model 5-H Portable Unit.

A.K. Robins and Company, Incorporated (Mr. Arnold S. Brodsky) - Even-Flo Hot Water Blancher, and Rotary Hot Water Blancher

Sweco, Inc. (Mr. Lester WRight) - Sweco Vibro-Energy Separator

Tranter, Inc., Texas Division (Mr. Jack Vander Ploeg) - Examples of Platecoil Heat Transfer Units

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PROCESSING VARIABLES AFFECTING COLOR DEVELOPMENT ON SMOKED MULLET

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INTRODUCTION

Color development of smoked fish results mainly from classical browning reactions involving carbonyl and amino groups (6,9). The amino acid lysine present in fish proteins is thought to supply the active amino group, whereas the carbonyls are present in wood smoke. Glycolic aldehyde, methylglyocol, formaldehyde and acetol are just a few of the aldehydes present in the gaseous phase of wood smoke. The particle phase (droplets) and phenolic compounds present in smoke are thought to play only a minor role in color development (9). Phenols exert their greatest influence in flavor development, while the droplets act as reservoirs for dissolved gases. Moisture, temperature, time, humidity, pH and smoke density are all factors influencing color development (4,5,6,7,9).

In general, the sequence of events leading to color development are absorption of active compounds from the gaseous phase onto the surface, followed by drying (cooking) and subsequent color formation. In that there are only four basic steps in fish smoking--brining, drying, smoking and cooking--each of these variables were investigated to determine their contribution to color development during the smoking of mullet.

MATERIALS AND METHODS

Mullet were obtained from Crystal River, Florida. The mullet were butterflied, rinsed and then brined at 45°F in solutions containing 0 or 4% salt for 16 hr. In studies involving 20% brine, the fish were soaked for 30 min. Fish-to-brine ratio was kept constant at 1:1.5. Brined fish were allowed to drain for 30 min prior to smoking in studies other than those investigating the effects of drying.

A 4% brine was utilized in the studies investigating the effect of a cook:smoke and smoke:cook process on color development. Following brining and a 30 min drying period, the fish were placed into the smokehouse (Koch, Grand-Price) with the vents open for the first 30 min, then the bottom vent was closed and the top vent was left half open for the remainder of study. In the cook:smoke process, the temperature was set at 150°F for the first hour, 175°F for the second hour, and then the smoke generator was started. The temperature for the third hour was raised to 200°F, and to 225°F for the fourth hour. When the fish were smoked:cooked, the same temperature schedule was followed; however, the smoke generator was on for the first two hours and then shut off for the last two hours. Internal temperature of the fish was approximately 165°F at the end of the heating cycle in both smoking protocols.

Sensory panels were composed of between 12 and 16 members for each trial. Chemical analyses followed AOAC (1) except for phenols which were done by the method of Tucker (10). Each study was conducted three times, and the results averaged for presentation of data.

RESULTS AND DISCUSSION

Of the four basic steps in the production of smoked mullet, only two exerted an effect on color in this study. These were brining and the timing of smoke application, both of which are related to the availability of moisture on the surface of the fish. While the literature (4,6,9) makes reference to the importance of humidity and moisture control on development of color in smoked foods, practical recommendations as to how these factors are influenced by processing are lacking. The chemistry of the reactions are well understood, i.e., amino groups reacting with carbonyl compounds present in the smoke. However, before this reaction can occur, the carbonyl compounds must be adsorbed from the smoke vapors, and a moist surface is necessary for this to occur (5,6,9).

This dependence upon moisture for absorption of the carbonyls can be related to those treatments which have a positive effect on color. Brining has been shown to increase moisture uptake as well as reduce moisture loss during smoking (8). Therefore, this step would ensure availability of the surface moisture necessary for adsorption of active carbonyls during the smoking and cooking step.

The data in Table 1 compare the effect of brining on color formation on mullet as well as some chemical parameters of interest. The panelists indicated that color was related to intensity of brining with the "no salt" treatment receiving the lowest score for color and the "20% brine" treatment receiving the highest score for desirability of color. These results clearly indicate the importance of a brining step in the formation of color during the smoking process. Both sensory observations on color and chemical analyses (phenols) indicated that smoke adsorption was greater with the brine treatments than without.

TABLE 1. Color and chemical analyses of "smoke:cook" mullet using different brine solutions

Brine NaCl %	Color	Phenol mg/10 g Sample	NaCl %	Moisture %
0	1.1	0.65	0	38.0
4	2.1	1.0	1.4	41.0
20	2.8	0.88	2.8	41.5

[1]Scale: 1 poorest to 3 the best.

The data for the effect of drying following brining are not shown. Within the times and temperature used in this study, we could find no

effect of presmoking drying on color. Drying times of 0 to 180 min at 45°F were selected as being applicable to the production of smoked mullet in Florida (3). That drying had no effect was somewhat surprising in that this step would be expected to lower surface moisture. It may have been that the times selected were too short and the temperature too low to bring about a marked loss of moisture. However, previous reports do stress that this drying period serves mainly to allow time for solubilization and migration of proteins to the surface for pellicle formation (2,3) during the heating of the fish.

Table 2 shows the sensory data for mullet prepared by both a cook:smoke and smoke:cook process. It can be seen that all attributes of the fish prepared by the smoke:cook process were scored higher than the cook:smoke process. During the early stages of smoke:cook process, ample moisture is available for adsorption of smoke vapors which is then followed by a heating and drying step necessary for color development. In the cook:smoke process, early drying of the surface occurs prior to application of the smoke, lessening the opportunity for smoke adsorption. It must be recognized, however, that depending upon the intensity of color desired, the smoking and drying step can be manipulated to obtain the desired color, as when preparing bloaters and buckling (4). Bloaters are dried for 3 hrs before smoking and develop only limited color, whereas buckling are smoked while still wet with brine in order to develop a golden brown color on the final product. The chemical data in Table 3 support the sensory data (Table 2), and it is interesting to note that phenol concentration correlated with sensory evaluation for both color and flavor.

TABLE 2. Sensory evaluation of smoked mullet prepared by a cook;smoke and smoke:cook process.

Treatment	Odor	Color	Texture	Flavor	General Acceptance
cook:smoke	6.5	5.8	6.5	6.4	6.2
smoke:cook	7.9	7.5	7.2	7.4	7.8

Scale: 9-point hedonic with 1 = dislike extremely, to 9 = like extremely.

TABLE 3. Chemical analyses of smoked mullet using two different smoking processes.

Treatment	Phenol mg/10 g Sample	NaCl %	Moisture %
cook:smoke	0.19	2.2	43.5
smoke:cook	1.0	1.9	41.0

Although adequate surface moisture is necessary for good color development, drying of the flesh during or following the smoking process is necessary for acceptable texture in the final product. If insufficient drying occurs,

the characteristic texture of smoked fish does not develop. Therefore, the proper balance of smoking, drying and cooking must be obtained for optimum quality.

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BROWN SHRIMP (PENAEUS AZTECUS) PACKED IN MODIFIED ATMOSPHERES CONTAINING CARBON DIOXIDE

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INTRODUCTION

General recognition of the benefits obtainable from the use of modified atmospheres in the handling of meats and fish is not recent. A significant increase in the shelf life of CO_2-packaged finfish was reported as far back as the 1930's by Coyne (5) and Killefer (10) and recently by Banks et al. (1) and Brown et al. (2).

The delay observed in the spoilage of fish is due to the selective inhibition of CO_2 towards bacterial populations; gram-negative microorganisms--particularly psychrotrophic spoilage bacteria--are more susceptible to CO_2 than are gram-positive bacteria (1,8,12); lactobacilli among them are able to grow at any CO_2 concentration used. Since lactobacilli usually outgrow gram-negative bacterial populations under modified atmosphere storage (11) and have different substrate requirements (7), the pattern of spoilage is different.

Several applications have been found for the use of CO_2 in fishery products. Yokoseki et al. (15) reported that CO_2 was useful in extending the shelf life of fish cakes. Carbon dioxide and propionic acid were used by Windsor and Thoma (14) as a means of preserving industrial fish prior to fish meal production. Veranth and Robe (13) reported that shipments of fresh salmon were sent successfully preserved from Alaska to Seattle in sealed trailers containing CO_2.

A number of advantages are offered by modified atmosphere packaging (MAP) of fresh fish in contrast to storage and distribution on ice:

1. Ice is replaced by salable product, lowering transportation cost;
2. The shelf life of the product is extended;
3. Direct contact with the product is avoided thereby reducing cross-contamination and mechanical damage;
4. Acceptance of retail stores to handle fresh fish increases since the packaging operation does not take place any longer in their own facilities.

The objectives of packaging brown shrimp in CO_2 under aerobic (CO_2/O_2) and anaerobic (CO_2, CO_2/N_2) conditions were to observe the development of blackspot, to determine the spoilage characteristics, and to measure the variation of CO_2 concentration in the package throughout the storage period.

MATERIALS AND METHODS

Brown shrimp (Penaeus aztecus) were packaged in preformed trays made of a plastic sheet consisting of a low gas permeability, polyvinylidene-chloride/polyethylene copolymer. The trays were evacuated, the selected gas atmosphere introduced and the transparent lid heat-sealed on the tray. The trays were subsequently stored at 4°C.

The composition of the gas atmospheres used in the experiment are listed in Table 1.

TABLE 1: Composition of the gas atmospheres used in the trays containing brown shrimp.

Treatment	$\%CO_2$	$\%O_2$	$\%N_2$
C10	100	--	--
C01	66	34	--
C02	38	62	--
CN1	65	--	35
CN2	35	--	65
AIR	--	20	80

Surface pH, total volatile nitrogen (TVN), bacterial counts and CO_2 concentration in the packages were determined on one tray representing each of the six treatments after 3, 6 and 10 days of storage. In addition, packages were also sampled for microbial counts after 14 days and for head-space CO_2 concentration after 14 and 19 days.

Total volatile nitrogen (TVN) was determined using the Conway microdiffusion method as described by Cobb et al. (3). Surface pH was measured with an Orion surface PH electrode.

A Tracor 560 gas Chromatograph (the column contained Porapak Q) was used to measure the CO_2 concentration in the head-space of the packages. After putting a rubber seal on the lid to prevent tearing of the film, a syringe needle connected to a small plastic hose was introduced in the package. A 1 ml sample was run through the column using helium as a carrier. A thermal-conductivity detector was used to measure the relative CO_2 concentration in the sample.

RESULTS AND DISCUSSION

In all samples packaged with CO_2, a lag phase that lasted up to 6 days (C10, C01, C02, CNI) was observed, whereas bacterial numbers on the air-packaged shrimp increased rapidly since the beginning (Figure 1). Assuming a bacterial load of 10^7 microorganisms/g as a limit for the shelf life of shrimp, the shelf life for air-stored shrimp would barely reach 4 days; for shrimp packaged in CO_2 it would reach from

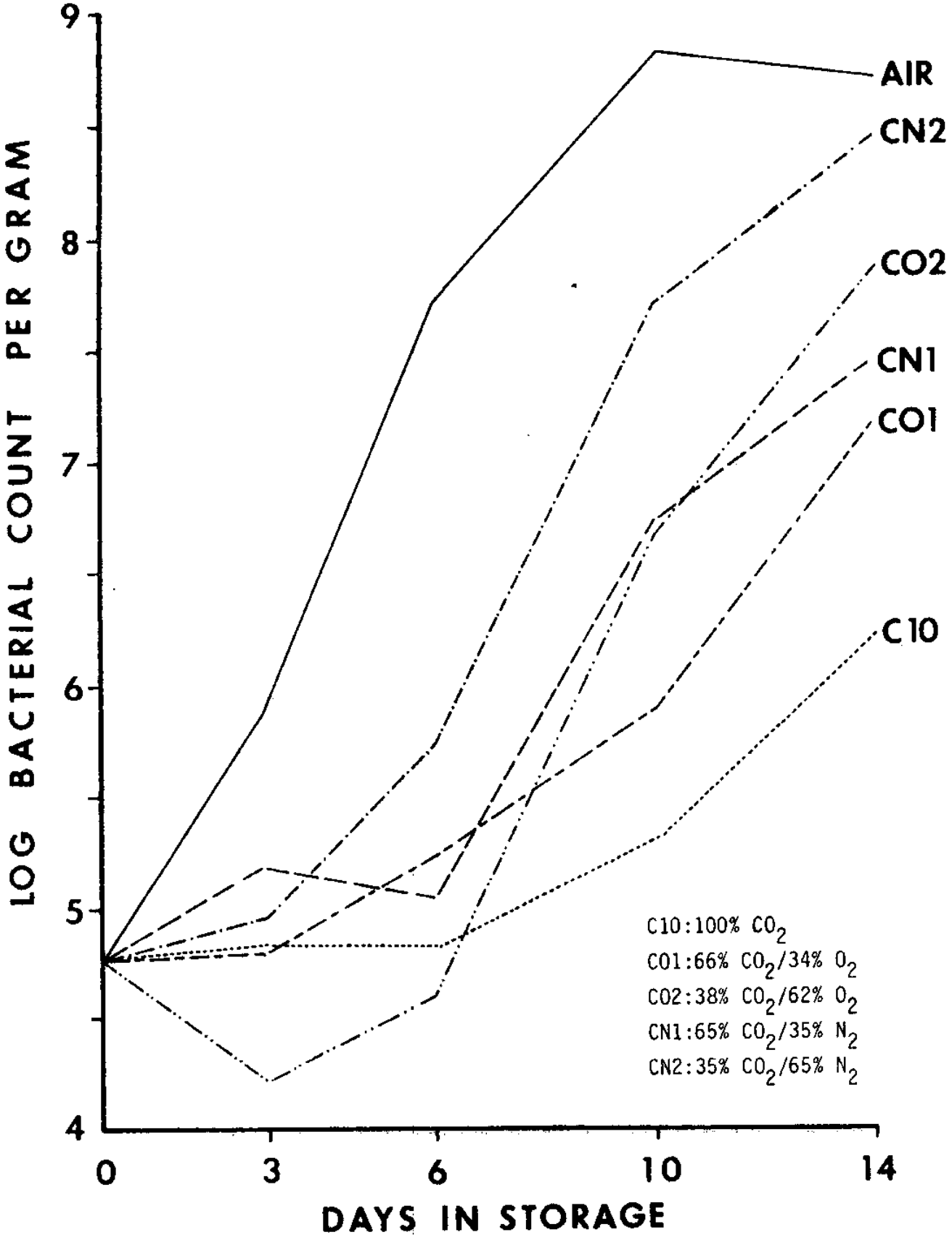

FIGURE 1. Aerobic plate counts of brown shrimp packed under modified gas atmospheres.

8 days (CN2) to more than 14 days. These results agree with those of Banks et al. (1), Brown et al. (2) and Killefer (10) who observed that CO_2 had a strong inhibitory effect against bacterial growth on fish.

A shelf life of 12-14 days can be expected of fresh shrimp. The rapid bacterial build-up on the MAP shrimp is probably a result of the absence of ice, which upon melting washed away bacteria that are present on the surface (4,9).

The gram-positive bacteria represented 31.1% of the initial microbial flora (Table 2), and this percentage decreased in all samples after 3 days of storage. At 10 days the percentage distribution of gram-positive bacteria increased drastically except for shrimp packed in air.

Gram-positive bacteria were rapidly outgrown by gram-negative microorganisms in the air samples. This did not occur in the samples containing CO_2 (except CN2) where after 10-14 days gram-positive bacteria represented at least 51.5% (CN1) of the total microbial population.

Carbon dioxide was effective in controlling the growth of gram-negative bacteria. Reproduction of gram-positive bacteria was also unhibited as can be seen when comparing gram-positive counts at 6, 10 and 14 days on air-stored shrimp to the counts on CO_2-packaged shrimp. A concentration of 100% CO_2 (C10) showed the greatest inhibitory effect against both gram-positive and gram-negative microorganisms, followed by shrimp stored in 66% CO_2/34% O_2 (Table 2).

The initial TVN value was high for fresh shrimp at 18.3 mg N/100 g (Table 3) and was a reflection of the relatively high initial bacterial numbers. For the first 6 days, the increase in TVN values was slow for shrimp packaged in CO_2 atmospheres. Total volatile nitrogen values of shrimp packaged in air increased more rapidly and after 10 days were 2 to 3 times as high as TVN values of CO_2-stored shrimp. A more rapid increase in TVN and ammonia content on fish stored in air was also observed by Banks et al. (1) and Brown et al. (2), respectively. The higher TVN value at day 10 for treatment CN2 reflects the higher number of bacteria on this sample as compared to the other shrimp stored in CO_2 (Table 2). The shelf life of shrimp kept on ice is usually considered to be around 14 days. However, on shrimp stored in air for 10 days bacterial numbers were above 10^8/g (Table 2) and the TVN content was 85 mg N/100g which indicated a spoiled, inedible product. This was probably caused by the absence of ice which, according to Cobb et al. (4) and Iyengar et al. (9), washes away bacteria on the surface upon melting.

A sharp decrease in the surface pH of the shrimp was observed when the CO_2 concentration used was 65% or higher. The decrease in pH is caused by formation of H_2CO_3 due to absorption of CO_2 at the tissue surface (1). After 3 days of storage, the pH started to increase in all but one sample (Figure 2). Surface pH of shrimp stored in air increased rapidly at first but after 3 days leveled off.

TABLE 2. Aerobic plate counts and gram-distribution of the microbial flora of brown shrimp packed under different gas atmospheres.

Treatment	Day	Aerobic Plate Counts	Gram-positive Population(*)	Gram-negative Population(*)
C 10	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	6.8×10^4	6.8×10^3(10.0)	6.2×10^4(90.0)
	6	6.8×10^4	5.4×10^3(8.8)	6.2×10^4(91.2)
100%CO_2	10	2.1×10^5	1.3×10^5(61.6)	8.1×10^4(38.4)
	14	1.7×10^6	9.7×10^5(57.1)	7.3×10^5(42.9)
CO 1	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	6.3×10^4	5.0×10^3(7.9)	5.8×10^4(92.1)
	6	1.7×10^5	4.5×10^4(26.7)	1.2×10^5(73.3)
66%CO_2/34%O_2	10	7.9×10^5	6.4×10^5(80.9)	1.5×10^5(19.1)
	14	1.6×10^7	1.4×10^7(84.7)	2.4×10^6(15.3)
CO 2	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	1.7×10^4	4.9×10^3(29.1)	1.2×10^4(70.9)
	6	4.2×10^4	2.2×10^4(52.4)	2.0×10^4(47.6)
38%CO_2/62%O_2	10	4.7×10^6	4.7×10^6(100.0)	---
	14	7.6×10^7	6.2×10^7(81.6)	1.4×10^7(18.4)
CN 1	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	1.6×10^5	2.1×10^4(13.1)	1.4×10^5(86.9)
	6	1.1×10^5	1.3×10^4(12.0)	9.7×10^4(88.0)
65%CO_2/35%N_2	10	5.6×10^6	1.9×10^6(33.9)	3.7×10^6(66.1)
	14	2.8×10^7	1.4×10^7(51.5)	1.4×10^7(48.5)
CN 2	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	9.1×10^4	1.0×10^3(1.1)	9.0×10^4(98.9)
	6	5.5×10^5	1.1×10^5(20.0)	4.4×10^5(80.0)
35%CO_2/65%N_2	10	5.1×10^7	1.7×10^7(33.3)	3.4×10^7(66.7)
	14	3.0×10^8	1.9×10^7(6.2)	2.8×10^8(93.8)
AIR	0	5.8×10^4	1.8×10^4(31.1)	4.0×10^4(68.9)
	3	7.4×10^5	1.6×10^5(21.6)	5.8×10^5(78.4)
	6	5.2×10^7	1.4×10^7(26.9)	3.8×10^7(73.1)
	10	6.9×10^8	1.9×10^8(27.5)	5.0×10^8(72.5)
	14	5.3×10^8	6.0×10^7(11.3)	4.7×10^8(88.7)

(*) Percentage distribution of microflora.

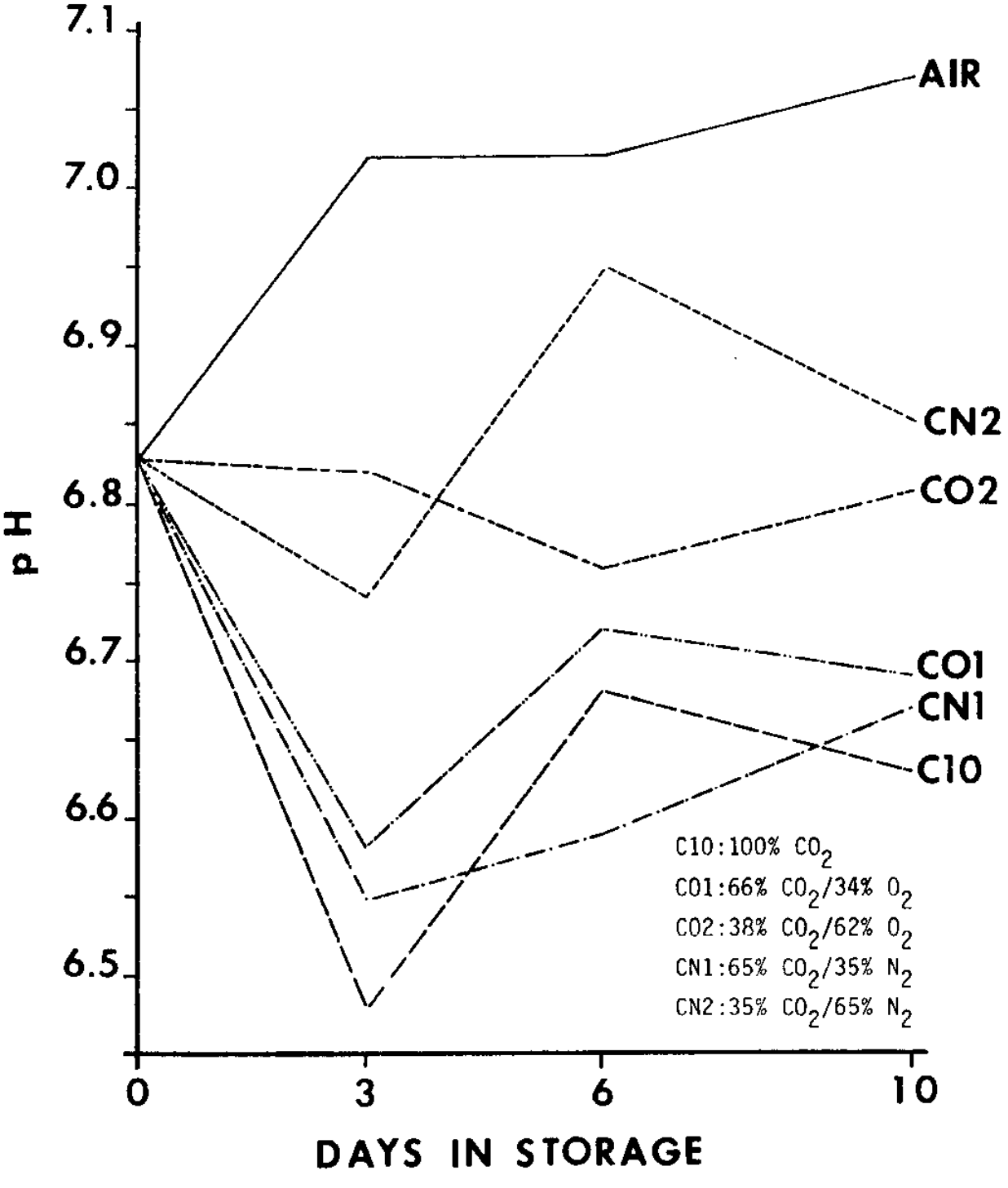

FIGURE 2. Surface pH of brown shrimp packed under different gas atmospheres.

TABLE 3: Total volatile nitrogen (TVN) of brown shrimps packed under different gas atmospheres

Treatments	D A Y S			
	0	3	6	10
C 10	18.3	22.4	25.6	30.5
CO 1	18.3	22.0	25.4	28.1
CO 2	18.3	22.2	24.6	31.5
CN 1	18.3	23.1	25.0	31.5
CN 2	18.3	22.0	24.0	47.8
AIR	18.3	24.2	29.5	85.0

C 10: 100% CO_2
CO 1: 66% CO_2 bal.O_2
CO 2: 38% CO_2 bal.O_2
CN 1: 65% CO_2 bal.N_2
CN 2: 35% CO_2 bal.N_2

The CO_2 concentration in the head-space of the packages decreased for the first 3 days of storage (Figure 3), probably due to the absorption of CO_2 at the surface of the shrimp in the form of carbonic acid. The subsequent increase in CO_2 concentration in samples containing O_2 was due to aerobic bacterial respiration whereas CO_2 production in CO_2/N_2 samples was probably caused by facultative or strict anaerobes which are able to produce CO_2 as a byproduct of their anaerobic metabolism (6). The rate of CO_2 increase was highest in the samples containing O_2, particularly shrimp packaged in air where the CO_2 concentration after 19 days was above 22%.

The development of black spot on the shrimp tails started after 6 days of storage and occurred more frequently in shrimp stored in CO_2/O_2 atmospheres as compared to air and the anaerobic packages, where a pink discoloration developed on the shrimp. This indicates once more that free O_2 is necessary in order for melanosis to develop.

CONCLUSIONS

Carbon dioxide was effective in inhibiting bacterial growth on shrimp when used in high concentrations. Even though more research is needed in this area, the development of black spot and discolorations, and the high content of volatile nitrogen on the shrimp packaged in CO_2 still seem to favor the use of ice to store and market this seafood.

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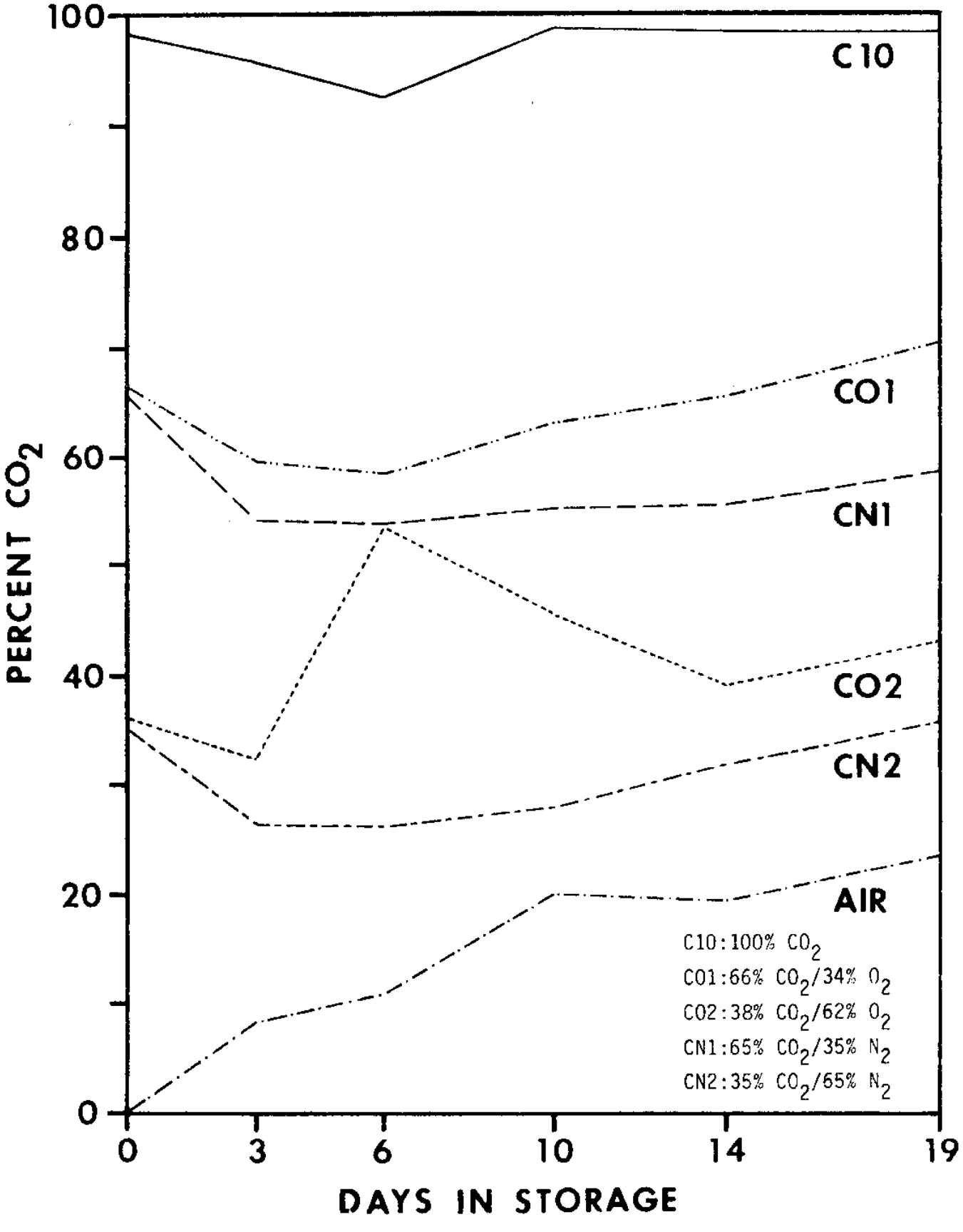

FIGURE 3. Carbon dioxide concentration in the head-space of packages containing brown shrimp stored under modified gas atmospheres.

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ON-BOARD QUALITY CONSIDERATIONS IN DEVELOPING NEW FISHERIES

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A transition into new fisheries and concepts is rapidly being experienced in the Texas fishing industry. Although shrimping remains economically the most important fishery in the United States, increases in operating expenses has limited the exploitation of this fishery to summer and fall months. As needs exist to continue fishing operations on a year-round basis, new fisheries are being pursued during times when shrimping is no longer feasible.

The exploitation of new fisheries often introduces unique quality control problems not confronted with traditional species. In traditional fisheries, fishermen are aware of the potential problems which they may confront in handling and maintaining the on-board quality of the seafood product they are harvesting. Although quality control often has capacity for improvement, rarely does an unexpected problem relative to quality surface.

One of the initial efforts directed toward fisheries development in Texas was that of royal-red shrimp, Hymenopenaeus robustus. Although substantial catches have been made in the northern Gulf of Mexico, certain inherent quality problems restrict this fishery to the near point of noncommercialization. Several unique characteristics have been responsible for the lack of success in marketing this resource. A problem identified with the shrimp is its bright red color. Paradoxically, this characteristic depicts spoilage in traditional, commercial shrimp species, therefore creating concern to uniformed consumers.

Another criteria which has hampered on-board handling of royal-red shrimp is the fragility of the shrimp. Crewmen have experienced special problems with breakage of the product. To compensate for the delicate nature of these shrimp, special attention is required in icing, unloading and processing. Several vessels directing efforts toward royal-reds have limited their unloading procedures to the obsolete "shovel and bucket" system. Modern pneumatic unloading systems have a tendency to increase breakage of the product. Table 1 depicts the size, composition and breakage (pieces) of royal-red shrimp during an evaluational voyage performed by the Texas A&M Marine Advisory Service. Machine grading, which was used in this assessment, subjected the fragile shrimp to additional breakage. As the table denotes, shrimp "pieces" command a significantly lower price than unbroken shrimp.

TABLE 1: Graded Composition of Royal-Red Shrimp, Hymenopeneaus robustus, from January, 1979 Evaluation Voyage.

Count Tails/Pound	% of Catch	Brownsville Packout Price/Pound*
15/20	5.3%	$5.40
21/25	33.3%	$4.61
26/30	19.4%	$4.26
31/35	0.0%	$4.05
36/42	16.3%	$3.70
43/50	5.9%	$3.27
51/60	5.6%	$2.75
Pieces	19.2%	$1.75

*Brownsville price January, 1979, for traditional commercial shrimp (not Royal-Reds).

Another quality problem of royal-red shrimp which industry confronted in the northern Gulf was the duration of the shrimping trip. Routinely, Gulf trawlers remain offshore for at least two weeks and experience no major degradation of shrimp maintained on ice. Fishermen directed efforts toward royal-red shrimp learned that this species deteriorated more rapidly. A rule of thumb of eight days on ice became the guideline, but only after several costly learning experiences.

Although royal-red shrimp production requires supplemental skills associated with trawl adjustment and operation, basic gear arrays remain fundamentally the same as that of traditional shrimping equipment. In the development of other new fisheries, in which entirely unfamiliar gear types or seafood species are involved, special considerations are imposed upon vessel crewmembers. Initial fishing efforts require more attention to gear and fishing techniques. In Texas, longlining for broadbill swordfish, Xiphias gladius, became an important new fishery in the winter of 1980. Although an established fishery in the Atlantic Ocean, local Texas fishermen were, originally, not proficient with swordfish longlining techniques. As a result of this unfamiliarity, retrieval of gear initially was slow; therefore, fish remained on the line or on deck for undesirable periods of time. Potential for quality problems resulted from inexperience in eviscerating and on-board processing of the fish resulted in additional delay before the product was refrigerated; moreoever, certain mistakes in cutting the fish or damage in handling resulted in reduced prices to the vessel.

Adaptations were rapidly enacted by numerous longline vessels. On maiden voyages, vessels began fishing reduced quantities of gear to speed time of retrieval. Modifications for handling fish on-board were directed to placing fish in the ice hold as they came out of the

water. Later they were removed and processed after gear was retrieved. Some vessels constructed canopies over the back deck to shade fish and pumped sea water over them continually until processed.

After preliminary cruises, some vessels added an additional crewmember, whose primary responsibility was to process fish as they were landed. Overall, experience derived from previous trips enhanced quality of Texas swordfish, as on-board efforts became more efficient.

Pelagic longlining for sharks is being evaluated by several Texas vessels. As this fishery is an adjunct from swordfish efforts, a foundation of experience and perspectives were established from inception. As sharks were observed in abundant quantities, extra crewmembers for processing have been employed. Concerns identified with on-board quality control have arisen. Shark fins are a marketable by-product from this fishery and a common mistake in method of removal has prevailed. Crewmen often cut too deeply when extracting; as a result, flesh was left attached to the cartilaginous fin. When dried aboard the vessel, unsanitary conditions were created as well as an odoriferous environment.

A positive quality measure on shark has been demonstrated and adapted. Immediately upon boarding sharks, the caudal fin is removed from the shark. As this severs major arteries to the tail, copious quantities of blood are immediately discharged from the shark. This measure also assists in subduing the fish.

Currently, major concerns exist among fishermen relative to quality of flesh between species of shark. With the exception of a higher price paid for mako sharks, Isurus sp., all the sharks are marketed in Texas at an identical ex-vessel price. It is impractical to differentiate several species after fins and head are removed. Much question exists relative to the desirability of one species over another. Due to differences in chemical composition among species, uncertainties arise relative to holding time on vessels. These are questions regarding quality control which must be addressed in order to develop an effective shark fishery.

Unique and opposing problems confront on-board preservation of products from developing fisheries in Texas. Swordfish markets require that the product not be frozen, but preserved on ice. Currently, 25% of the ex-vessel value of the fish is deducted if frozen. Correspondingly, the Texas ex-vessel value of red snapper, Lutjanus campechanus, is relinquished if the product is frozen. This has important consequences to several freezer vessels in Texas, as they have recently entered into longlining fisheries for snapper and swordfish.

Conversely, the value of Atlantic bluefin tuna, Thunnus thynnus, is significantly diminished if landed unfrozen. Although harvested as an incidental bycatch to that of swordfish, bluefin tuna represent a high value commodity. Several of these giant fish, preserved with ice, have brought individual prices in excess of $2,000 apiece. Sold to oriental markets, quality of these fish must be maintained to an extraordinary degree. Texas vessels are required to land iced blue-

fin within three days from harvest in order to receive 25-50% of the price that is paid for the frozen product. Japanese vessels longlining these fish maintain these fish at approximately -50°C. Although Texas vessels are not equipped with comparable freezing equipment, the product could be landed in a more marketable condition if frozen. As the vessels have swordfish aboard, conflicting circumstances arise. Another quality consideration regarding icing of bluefin tuna, caught in Texas, is vessel hold space. Vessels participating in longlining are typically shrimp trawlers. The majority of vessels do not have ice bins large enough to accommodate these massive fish. As a result, fish must be iced in the alleyway of the ice hold. This can create quality problems if copious quantities of ice are not utilized in insulating the fish from contamination. Necessary crew movement within the hold to re-ice fish, obtain bait and other related activities, must be done around the fish iced in the alleyway.

Other variables of quality control have been confronted with Atlantic bluefin tuna. At the close of the longline season in May, 1980, the price of bluefin tuna decreased substantially. Reports from oriental buyers were that the chemical composition of the fish underwent changes due to spawning activities.

During trials for bottom longlining of golden tilefish, Lopholatilus chamaeleonticeps, fish size represented an important quality consideration. Proportionally, yields of fillets from larger fish are more desirable than those from smaller individuals.

Through harvesting evaluations, larger fish were determined to be more prevalent in the deeper waters of the range of the tilefish. As a result, fisheries endeavors have concentrated on quality fish in their designated depths.

Pricing structures relative to fish size have affected the newly developed longline fishery for red snapper. This fishery has been confined to areas of soft, muddy bottom. A phenomenon occurs in the Northwestern Gulf of Mexico whereby larger red snapper inhibit these areas during the spring months. The majority of longline sets made on these grounds yield snapper in excess of 15 pounds. Market limitations for these larger fish in Texas have hampered the fishery.

Heavy metals have had important consideration in the development of new fisheries in the Gulf of Mexico. Regulations and guidelines relative to mercury in swordfish prevented several Texas vessels from entering the fishery at a much earlier date. It was only when these guidelines were modified to a more liberal level that local vessels began to explore opportunities within the swordfish industries.

Attempts in 1976 to develop a fishery for blackfin tuna, Thunnus atlanticas, were initially hampered by heavy metals. Fish landed of an exceptionally large size were evaluated for mercury. The content of these fish exceeded prescribed standards. Only when further evaluations of blackfin tuna were performed was the fishery launched in 1980.

Although the previously mentioned quality problems have been confronted during fisheries development efforts, very few of these

difficulties lack solutions. Of major importance is the ability to anticipate and plan for quality problems which may be encountered in a new fishery. From a production standpoint, it is more advantageous to be capable of handling more product than is harvested. Being unprepared and unable to effectively process and maintain quality, the catch can ultimately damage a new fishery in its inception.